# PHYSICAL GEOGRAPHY,

## In Two Parts.

PART I.

GENERAL PHYSICAL GEOGRAPHY.

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PART II.

PHYSICAL GEOGRAPHY OF INDIA,

WITH AN APPENDIX.

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Compiled for the Use of Schools,

BY

M. W. WOOLLASTON.

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# PHYSICAL GEOGRAPHY.

## CHAPTER I.

### GENERAL OBSERVATIONS.

PHYSICAL or *natural* geography might, if we regarded merely the strict meaning of the words, be limited to signify no more than a description of the principal features of the earth's surface; but it is usual, in treatises upon this branch of geography, to touch also upon the subject of climate and temperature,—to show how these, together with other natural causes, affect the condition of the human race—and to advert, in a general manner, to the animals and productions of the globe.

*Geographical terms explained.*

In looking over a map of the world, it is seen at once that the surface consists of various spaces of *land*, surrounded by an extensive field of water called the *sea* or *ocean*. Of these spaces of land, two are of vast extent, and on this account are termed *continents**, (derived from a Latin word signifying, *holding together* or *con-*

* New Holland, by some geographers, is regarded as a third continent; but if we consider how much smaller it is than either of the two vast tracts abovementioned, it will appear correct rather to assign it the first station among the *islands* of the globe. New Holland and the islands around it are, however, not unworthy of being classed as the 5th grand division of the world. English geographers have named them *Australia* (that is, *Southern lands.)*

*nexion*). The larger of these continents includes the three divisions of Europe, Asia, and Africa, and is distinguished by the title of the *old continent*, from its having, till the discovery of America, by Columbus, in the year 1492, been the only one with the existence of which Europeans were acquainted. The other, which includes North and South America, is named the *new continent*. The smaller portions of land which are scattered over the ocean are denominated *islands*. A great many islands lying together are called an *archipelago*.

In many places the land and the ocean run one into the other. When the ocean penetrates into a continent by a narrow passage, and then spreads again into a large expanse, this inland portion of the ocean is usually termed a *sea*. If the extent of such an inland sea be less, or the passage by which it communicates with the main ocean larger, it is called a *gulf* or *bay*. An inland body of water not connected with the ocean or any of its branches, is called a *lake*. A narrow passage of water leading from one sea to another is called a *strait*; a narrow neck of land lying between two seas, and connecting two masses of land greater than itself, is called an *isthmus*. When, on the other hand, a part of a continent runs out into the sea, and is joined to the main land by only a small portion of its circumference, it is named a *peninsula*, (that is, an *almost island*). If the projections of land reach but a little way into the sea, they are called *capes*, *headlands*, or *promontories*.

*General View of the Globe as consisting of Land and Sea.*

There is, in fact, only one continuous fluid surrounding the land, all the gulfs and inland seas being branches* of this universal ocean; but for the sake of convenience different parts of it have distinct names given to them. The following table, exhibiting the principal seas into which the ocean has been divided, will be clearly understood upon referring to the map of the world on Mercator's projection:—

* The Caspian *Sea*, as it is generally termed, forms no exception to this remark, because it is in fact only an immense lake.

1. The *Antarctic Ocean*, which is comprised within the Antarctic circle, that is, between the parallel of 66° 32′ of southern latitude and the South Pole.

2. The *Southern Ocean*, the boundary of which on one side is the Antarctic circle, on the other a line drawn from Cape Horn to the Cape of Good Hope, thence to Van Diemen's Land, and again by the south of New Zealand to Cape Horn, this line forms the southern boundary of Nos. 3 and 4.

I. The great *South eastern* basin, the waters of which cover nearly half the globe. It includes.

3. The *Indian Ocean*, lying between Africa on the west, and the peninsula of Malaya with the islands of Sumatra, Java, &c., and New Holland, on the east, and bounded by Persia, and Hindustan on the north. The Red Sea, or Arabian Gulf, the Persian Gulf, and the Bay of Bengal are all parts of this ocean.

4. The *Pacific Ocean*, divided by the equator into *North* and *South*, and inclosed between America on the east, and New Holland, the islands of Java and Sumatra, and the continent of Asia, on the west. On the north it terminates at Behring's strait. The seas of China, Japan, Okhotsk, &c. form parts of this ocean.

II. The *Western* basin, forming a channel between the old and new continents.

1. The *Atlantic Ocean*, commencing in the south from a line drawn from Cape Horn to the Cape of Good Hope, and terminated on the north by the Arctic circle. It is divided into *North* and *South* by the equator, and its branches are the Mediterranean, the North Sea or German Ocean, the Baltic, Baffin's Bay, Hudson's Bay, the Gulf of Mexico and the Caribean Sea.

2. The *Arctic Ocean*, surrounded the North Pole, and bounded by the Arctic circle and the northern shores of the two continents. The white Sea, the sea of Kare, and the Gulf of Obe are parts of it.

The Ocean is spread over nearly seven-tenths of the globe; but it is remarkable how unequally the land and water are distributed. If we look at a map of the world projected upon the horrizon of London, in which map, cansequently, London forms the centre of the one hemisphere and the antipodes* to London, the centre of the other; the first hemisphere, it will be seen, contains a very large proportion of the whole of the land, while the second, if we except New Holland and the extremity of South America, from the twenty-ninth degree of south latitude, consists almost entirely of water. The distribution of water and land is still very unequal, if we compare only the northern and southern hemispheres, that is, the two equal parts into which the globe is divided by the equator. The following calculation will plainly exhibit this fact:

| | |
|---|---|
| Considering the whole space included in the northern part of the torrid zone, as equal to 1, the proportion of land is... | 0.297 |
| On the same supposition, the proportion of land in the northern temperate zone is... | 0.559 |
| And in the northern icy zone... | 0.400 |
| In the southern part of the torid zone, the portion of land is... | 0.312 |
| In the southern temperate zone... | 0.075 |
| In the southern icy zone (supposed)... | none. |

In other words, if the quantity of land in the northern hemisphere be represented by 16, the quantity in the southern will be scarcely equal to 5.

About the middle of the last century it was asserted that a great continent must exist towards the south pole, in order to counterbalance the mass of land in the northern hemisphere; but by the voyages of Cook and others, it has proved that the high southern latitudes contain only a few islands.—The absence of a continent near the south pole does not of itself prove that there is less land there than in the north, since it is possible that the land in general may be only rather more depressed in the south,

* A small island lying to the south-east of New Zealand, and called Antipodes island, is very nearly the antipodes to London.

the necessary result of which would be that the ocean would spread itself more extensively over the surface of the earth in that quarter.

*On the Figure, &c., of the Continents.*

The general direction of the land in the two continents is entirely different. In America, it is from pole to pole; in the old world, it is from south-west to north-east, and, if we keep Africa out of view, it is almost parallel to the equator. The longest straight line that can be drawn on the old continent commences on the western coast of Africa, from about Cape Verd, and extends to Behring's strait in the north-east of Asia. It is about 11,000 miles in length. A similar line, traced along the new continent, passes from the strait of Terra del Fuego, to the northern shore of North America, and is nearly 9,000 miles long. In both continents the direction of the large peninsulas is similar, almost all of them running towards south. This is the case with South America, California, Florida, Alaska, and Greenland in the New World, and in the Old with Scandinavia, Spain, Italy, Greece, Africa, Arabia, Hindustan, Malaya, Cambodia, Corea, and Kamtchatka. The only exceptions to this remark, are the peninsula of Yucatan in Mexico, and that of Jutland in the north-west of Europe. Both of these are directed towards the north; but they consist of plains and alluvial land, whereas the other peninsulas are more or less of a mountainous character. There is a further resemblance between the two continents, from each being divided into two parts by an isthmus*; but in the character of their outlines they differ very much: for while the coast of the Old World (independent of Africa) is broken equally on all sides by gulfs, bays, and inland seas, the New World has a series of openings on its eastern shore only. Of its western side, the only inlet of any magnitude is the gulf of California.

* The isthmus of Suez is composed of sand; that of Panama or Darien consists of stupendous rocks.

## Section 1.

## MOUNTAINS.

If the earth were perfectly level there could be no rivers; for water can flow only from a higher to a lower place; and instead of that beautiful variety of hills and valleys, verdant fields, &c., which serve to display the goodness and beneficence of the Deity, a dismal swamp would cover the whole face of the earth, and render it at best an habitation for aquatic animals only.

Mountains may be divided into two classes:—First, those of which the chains are the most lofty, rugged, and extensive, such as the Andes, in America; the mountains of Central Asia, the Alps, &c.; and secondly, those of a less majestic nature, and which appear to form branches of the first. Of this kind, are the Appenines, which traverse the whole length of Italy, and the Carpathian range which nearly surrounds Hungary.

Most mountains are connected together, and hence are called *chains*, but some are completely insulated. Volcanos are generally of the latter kind.

Mountains are composed of various kinds of rocks and earths, such as granite, gneiss, slate, basalt, porphyry, limestone, &c.

The oldest are generally composed of granite, which forms the bars on which the various strata or beds of other earths and rocks repose.

In regard to their formation mountains are distinguished into primitive and secondary formations. The primitive are composed of the hardest rock, and occupy the axis or central part of the mountain, while the various coats of earth or rock which lay over the centre in distinct layers, like the coats of an onion, are called secondary formations. Thus the highest points of the Alps consist of granite. Chimborazo and Antisana are crowned with vast walls of porphyry.

Most of the mountains have one of their sides very steep and the other of a gradual slope. Their steepest sides are generally those nearest to the sea, consequently

their inclination is most gradual towards the interior of the country in which they are situated.

The following is a list of some of the highest mountains in the world.

### EUROPE.

| | | Feet. |
|---|---|---|
| Alps. | Mount Blanc, above the level of the sea...... | 15,668 |
| | Mount Rosa ..... ........................ | 15,527 |
| | Ortler Shetze in the Tyrol.................. | 15,430 |
| Pyrannees. | Perdu............................ .... | 11,275 |
| | Nethan............... ............... | 14,427 |
| | Canyan................................ | 9,145 |

### ASIA.

| | | Feet. |
|---|---|---|
| Dhawalgiri.... | HIMALAYA ............... | 28,077 |
| Sewahu....... | HIMALAYA ............... | 25,747 |
| Mona Roa...... | SANDWICH ISLANDS......... | 15,988 |
| Ophie.......... | SUMATRA................ | 13,840 |

### AFRICA.

| | | Feet. |
|---|---|---|
| Geesh........ | ABYSSINIA ........................... | 15,000 |
| Anna Anna... | ABYSSINIA ................. | 13,000 |
| Lamalmon .... | ABYSSINIA ....... .................... | 11,200 |

### AMERICA.

| | | Feet. |
|---|---|---|
| Chimborazo .. | ANDES ......................... | 21,425 |
| Cayambe..... | ANDES ................ ... | 19,633 |
| Antesanu*.... | ANDES ............... | 19,136 |
| Cotopaxi*..... | ANDES ........................ | 18,857 |
| Farm of Antisana, (inhabited)............. | | 13,435 |

These mountains, although very considerable, irregularities with regard to us, are nothing when compared with the magnitude of the globe. Thus, if an inch were divided into 111 parts, the elevation of Chimborazo, on a globe of 18 inches in diameter, would be represented by *one* of the 111 parts.

Men have not been able to penetrate above a mile below the surface of the earth; but it has been found that this crust is composed of beds of different materials, arranged according to certain laws;—that these beds are sometimes divided by immense fissures or rafts in a *perpendicular*, and sometimes in an *inclined* direction. Some of these fissures or dykes are filled with stony substances; but the most useful and interesting features in

NOTE.—Those marked * are *volcanos* or burning mountains.

the crust are the metallic veins, whence the various metals are extracted.

The tops of the mountains are covered with perpetual snow, and when the summer heat dissolves a portion of it, the dissolved snow flows down in rapid streams, swelling the rivers, and producing violent currents.

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## SECTION II.

## VOLCANOS.

The term Volcano (derived from Vulcanus, the name which the Romans gave to their imaginary God of Fire), is applied to those mountains which send forth from their summits or sides, flame, smoke, ashes, and streams of melted matter, called *lava*. Upon ascending to the top of a mountain of this kind, there is found to be an immense deep hollow, called the *crater* or *cup*. The smaller volcanos are generally the most terrific in their effects. Stromboli, in the Lipari islands, is almost always burning. Vesuvius, in Naples, has more frequent eruptions than Etna. While the immense summits of the Andes and Cotopaxi have hardly one eruption in a century. The volcanos of America, besides the common lava and rocks, &c., cast out scorified clay, carbon, sulphur and water, accompanied in some instances by fishes.

The eruption of Vesuvius in the year 79 overwhelmed the two famous cities of Herculaneum and Pompeii by a shower of stones, cinders, ashes, sand, &c., and totally covered them many feet deep as the people were sitting in the theatre. The former of these cities was situated about four miles from the crater, and the latter about six.

By the violence of this eruption, ashes were carried over the Mediterranean Sea into Africa, Egypt, and Syria; and at Rome they darkened the air on a sudden so as to hide the face of the sun. But what is very remarkable, these two cities, Herculaneum and Pompeii, after a period of nearly 1800 years, have been as it were disinterred. The latter indeed has been so laid open as

to discover almost the entire city with its splendid buildings, streets, &c., entire. Pompeii was buried by a shower of ashes, pumice, and stones, forming a bed of variable depth, but seldom exceeding 12 or 14 feet.

The upper stories of the houses, which appear to have consisted chiefly of wood, were either burnt by the red hot stones, ejected from Vesuvius, or broken down by the weight of matter collected on their roofs and floors. With this exception, we see a flourishing city in the very state in which it existed nearly eighteen centuries ago: the buildings as they were originally designed, not altered and patched to meet the exigencies of newer fashions; the paintings undimmed by the leaden touch of time; household furniture left in the confusion of use; articles even of intrinsic value, abandoned in the hurry of escape, yet safe from the robber; and in some instances, the bones of the inhabitants, bearing sad testimony to the suddenness and completeness of the calamity which overwhelmed them.

It is remarkable, that in the old continent, the principal chains of mountains contain no valcanos, and that islands and the extremities of peninsulas are alone the seats of these convulsions; while in the New World the immense range which runs along the shore of the Pacific ocean possesses more volcanos than are to be met with in the whole of the old continent and its adjacent islands. Professor Jameson has given the following estimate of the number of volcanos.

| | |
|---|---|
| Continent of Europe | 1 |
| Islands of ditto | 12 |
| Continent of Asia | 8 |
| Islands of ditto | 58 |
| Continent of America | 97 |
| Islands of ditto | 19 |

None have been found in the continent of Africa, but most of its groups of islands are distinguished by them.

The principal volcanos are those of Etna in Sicily, and Vesuvius, before noted. Also from Terra del Fuego (the land of fire) to the peninsula of Alaska, a complete series of volcanos may be traced. There are many formidable

ones in Kamtchatka, the islands of Japan and Formasa, St. Paul, Amsterdam, and Bourbon. Iceland has suffered frequently from the terrific eruptions of its volcanos. In some places, parts of the land which are covered by the waters of the ocean are seats of volcanos; and it has sometimes happend that new islands have been formed during submarine eruptions. A recent instance of the kind occurred in 1811, in the neighbourhood of St. Michael, one of the Azores. This new island has since disappeared. Still more recently, about five years ago, one suddenly rose in the Mediterranean, and still exists. Some mountains bear marks of having been the outlets of fires; and on this account are called *extinct* volcanos.

Vast masses of earth sometimes sink down during volcanic eruptions. The Pahandayary, situated towards the western extremity of Java, was formerly one of the largest volcanic mountains of the island, but the greatest part of it was swallowed up in the earth, in the year 1772. It is asserted, that on the night of this event, an uncommonly luminous cloud was seen to envelope the mountain. Alarmed by this appearance the inhabitants on the declivities and about the foot of the mountains took to flight, but before they could all save themselves it began to give way, and the greatest part of it actually *fell in* and disappeared in the earth. A tremendous noise and the discharge of showers of volcanic substances accompanied this commotion. An extent of land fifteen miles long and six broad was thus swallowed up in the bowels of the earth.

To account for these phenomena Dr. Daubany, Professor of Chemistry in the University of Oxford, has lately brought forward a theory which is founded on the metallic nature of the base of the earth and alkalies, and the avidity with which these combine with oxygen, producing in that combination a high temperature, and strong inflammation. It is supposed, that if these materials exist in sufficient quantity in the interior of the earth, and a sufficient body of water be admitted to them, *judging from the violent effects on a small scale which we are able to produce by experiments,* a heat

would be engendered quite adequate to occasion all that takes place in volcanic eruptions. Now under this hypothesis it is requisite that water should have access to the metallic basis, and it is a curious fact that nearly all active volcanic groups are within a short distance of the sea; while even those in South America, which must be excepted from this remark, are in a range of mountains approaching in parts close to the sea. A further argument in favour of the present view, is, that all the products which Chemists know to be the result of the admission of sea water to the metallic basis, appear, under some form or other in every volcanic eruption.

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## Section III.

## EARTHQUAKES.

Earthquakes are another great cause of the changes made in the earth. Pliny the historian has recorded several instances which happened in his own time.

1. A city of the Lacedemonians was destroyed by an earthquake, and its ruins wholly burried by the mountain Taygetus falling down upon them.

2. The greatest earthquake mentioned in history was that which happened during the reign of Teberius Cæsar, when twelve cities of Asia were laid level in one night.

3. In modern times the great earthquake of Lisbon and that of Calabria appear to have been the most awful.

They appear to be brought about by the same causes as volcanic eruptions, but their action is much more tremendous. They are frequently accompanied by loud subterraneous noise, and are sometimes so violent that the ground heaves up, and undulates like an agitated sea. They are felt almost at the same instant, over a most astonishing extent, and yet do not last above one or two minutes. In those parts which appear to be near the centre of their action, the most calamitous effects sometimes occur; whole cities are destroyed, and their inhabitants burried beneath the ruins; the surface of the earth undergoes violent changes; springs are stopped

and others gush out in new places; fissures are made in the earth; and enormous masses of rock and other materials sent down, or are detached from the mountain. Sometimes the sea is violently agitated, rising on some occasions twenty feet, and suddenly falling at other times; the sea recedes and leaves the vessels dry at a considerable distance from the land. As in volcanos so in earthquakes, the worst are generally near the sea coast; instance those of Lima, Lisbon, and Caraccas.

It is generally supposed that earthquakes are produced by the disengagement of elastic vapours, which, endeavouring to escape from their confinement heave up and agitate the crust of the earth.

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## SECTION IV.

## VALLEYS AND PLAINS.

Valleys are the spaces lying between opposite sides o mountains or of hills, and their lowest part is commonly the bed of some torrent or river which originates in the higher grounds. Those between high mountains are in general narrow and long, resembling large clefts or fissures.

The narrow openings which are the entrance to the high valleys are called *passes* or *defiles*, and these are often of the most gloomy and terrific aspect.

Plains are of two kinds. Those which are extensive but very elevated, come under the denomination of *table land.* There are several plains of this sort, but the most remarkable are those among the Andes; the plains of Quito are 12,000 feet above the level of the sea; also those of Mexico and the immense plains in Central Asia to the N. and N. E. of Hindustan. The great Himalayan and Allacan chains form the ramparts, as it were, of this extensive and desolate table land, a large proportion of which is the desert of Gobi. The *low plains*, from the nature of their soil seem formerly to have been covered by the sea. The large plain to the south of the Baltic, is one out of several instances of this character.

## Section V.

## ISLANDS.

Many islands, especially those in the South Sea, owe their origin to the marine insects which produce the coral. Some are raised by volcanic action. Some perhaps are only the summits of extensive submarine chains of mountains. It has been supposed that, among others, the West India Islands and the Archipelago between New Holland and the opposite coast of Asia, were rendered insular by an incursion of the ocean having detached them from the continents to which (if the supposition be just), they formerly belonged.

Islands of volcanic formation are few, but those which owe their origin to marine insects of the class of Zoophytes, or plant animals, are innumerable. The following is an account of their formation, extracted from Captain Basil Hall's Narrative of his Voyage to the Loo Choo Islands.

"The examination of a coral reef during the different stages of one tide, is particularly interesting. When the tide has left it for some time, it becomes dry, and appears to be a compact rock, exceedingly hard and rugged; but as the tide rises, and the waves begin to wash over it, the coral worms portrude themselves from holes which were before invisible. These animals are of a great variety of shapes and sizes, and in such prodigious numbers, that in a short time, the whole surface of the rock appears to be alive and in motion. When the coral is broken about high water mark, it is a solid, hard stone; but if any part of it be detached at a spot which the tide reaches every day, it is found to be full of worms of different lengths and colours; some being as fine as a thread and several feet long, of a bright yellow, and sometimes of a blue colour.

"The growth of coral appears to cease when the worm is no longer exposed to the washing of the sea. Thus a reef rises in the form of a cauliflower, till its top has gained the level of the highest tides, above which

tne worm has no power to advance, and the reef, of course, no longer extends itself upwards."

The other parts in succession reach the surface, and there stop, forming, in time, a level filled with steep sides all round. The reef, however, continually increases, and being prevented from going higher, extends itself ~~literally~~ in all directions. But this growth being as rapid at the upper edge as it is lower down, the steepness of the face of the reef is still preserved. These are the circumstances which render coral reefs so dangerous in navigation; for, in the first place, they are seldom seen above the water; and in the next, their sides are so steep, that a ship's bows may strike against the rock before any change of soundings has given warning of the danger.

Captain Flinders, who in 1801, made a survey of the coasts of New Holland, has made some observations upon the formation of coral islands, particularly of Half Way Island on the north coast of that region, which show, how, after being raised up, they gradually acquire a soil and vegetation.

"This little island, or rather the surrounding reef, which for three or four miles long affords shelter from the south east winds, and being at a moderate day's run from Murray's Isles, it forms a convenient anchorage for the night to a ship passing through Torres Strait—I named it Half Way Island. It is scarcely more than a mile in circumference, but appears to be increasing both in elevation and extent. At no very distant period of time it was one of those banks produced by the washing up of sand and broken coral, of which most reefs afford instances, and those of Torres Strait a great many. These banks are in different stages of progress; some like this, are become islands, but not yet habitable. Some are above high water mark, but destitute of vegetation; whilst others are overflowed with every returning tide.

"It seems to me that when the animalcules which form the corals at the bottom of the ocean cease to live, their structures adhere to each other, by virtue either of the glutinous remains within, or of some property in

salt water; and the interstices being gradually filled up with sand and broken pieces of coral washed by the sea, which also adhere, a mass of rock is at length formed. Future races of these animalcules erect their habitations upon the rising bank, and die in their turns to increase, but principally to elevate this monument of their wonderful labours. To be constantly covered with water seems necessary to the existence of the animalcules, for they do not work except in holes upon the reef, beyond low water mark; but the coral, sand, and other broken remnants thrown up by the sea, adhere to the rock, and form a solid mass with it as high as the common tides reach. That elevation surpassed, the future remnants, being rarely covered, lose their adhesive property; and remaining in a loose state, form what is usually called a *key*, upon the top of the reef. The new bank is not long in being visited by sea birds; salt plants take root upon it, and a soil begins to be formed; a cocoanut, or the drupe of a pandanus is thrown on shore; land birds visit it, and deposit the seeds of shrubs and trees; every high tide, and still more, every gale, adds something to the bank till the form of an island is gradually assumed; and last of all, comes man to take possession."

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## CHAPTER II.

### OF THE WATER.

#### SECTION I.

Of the Ocean—Its Saltness and Temperature;—Tides and Currents.

That vast body of water which surrounds the continents, and is the common receptacle of their running waters, is indispensably necessary to the support of animal and vegetable existence upon the earth. Its perpetual agitations purify the air, and the vapours which the atmosphere draws up from its surface being condensed and dispersed through the upper regions, form clouds, which are the sources of a constant supply of rain and

moisture to the land. The ocean also, by the facilities for communication which it offers, is the means of uniting the most distant nations, which it enables them to interchange with mutual advantage the productions of their several climates.

The bottom of the sea appears to have similar inequalities to the surface of the continents; the depth of the water is therefore, extremely various. There are vast spaces where no bottom has been found, but this of course, does not prove, that the sea is bottomless, because the line is able to reach, but a comparatively small depth. Lord Mulgrave, let down, in the Northern Ocean, a very heavy sounding lead, and gave out with it nearly 4,700 feet of rope without finding the bottom; and Mr. Scoresby mentions having sounded in the Greenland Sea as much as 7,200 feet. Such experiments however, must be of very doubtful character; it is well known how much more easily bodies may be moved along in the water than in the atmosphere, and consequently, any current would be sufficient to carry the lead with it, and so draw the rope out of a perpendicular direction. If we were to found our opinion upon analogy, we might conclude that the greatest depth of the ocean, is, at least, equal to the height of the loftiest mountains, that is, between 20,000 and 30,000 feet.

The level of the sea, if it were not for the action of external disturbing causes, would be the same every where at the same instant, owing to the equal pressure exerted by the particles of a fluid upon each other in every direction. The figure assumed by the ocean would, therefore, exhibit the true surface of our planet, that of an oblate spheroid. But it is evident that no general level of this kind can ever exist, because the tide at any given moment is at very different heights in different parts of the ocean. The level is also continually being disturbed by the operation of the wind in particular regions.

The waters of the Red Sea, on the east side of the Isthmus of Suez, were found by some French Engineers to be 32½ feet higher than those of the Mediterranean

on the opposite side of the same Isthmus, in consequence of the accumulation which arises from the water being driven into these confined inlets by the general movement of the sea from east to west. Of certain inland seas, the level varies with the seasons. The Baltic and the Black Sea, which are in fact almost lakes, swell in the spring, from the abundance of water brought down to them at that period by the rivers. The general colour of the sea is a deep bluish green which becomes clearer towards the coasts. The Mediterranean, in its upper part, is said to have at times a purple tint. In the Gulf of Guinea, the sea is white; around the Maldive Islands, it is black; in some places it has been observed to be red, and in others yellow. These appearances are probably occasioned by vast numbers of minute marine insects, by the nature of the soil, or by the infusion of certain earthy substances in the water. The yellow shade, in the Yellow Sea, is said to be in consequence of the shallowness of the water in that place.

The component parts of the ocean in addition to pure water are marine acid, sulphuric acid, or vitriol, fixed mineral alkali, magnesia, and sulphated lime. By boiling, or evaporation in the air, common salt is obtained.

Dr. Thomson states that the proportion of salt in water, taken up by Lord Mulgrave, at the back of Yarmouth Lands, was 3.125 per cent. of the weight of water. The sea is generally less salt at the surface than towards the bottom; and also less towards the poles than at the equator.

In consequence of the greater specific gravity of salt water compared to fresh bodies, are much more buoyant in the former than in the latter.

| | |
|---|---|
| Distilled water, specific gravity is.............. | 1,000 |
| Purest spring water........................... | 1,005 |
| River water.............................. | 1,010 |
| Sea water................................ | 1,028 |

Springs of fresh water in some places rise up in the midst of the sea; Humboldt mentions that in the Bay of Xagua, on the southern coast of Cuba, springs of this

kind gush up with great force at the distance of two or three miles from the land.

Water being a bad conductor of heat, the temperature of the sea changes much less suddenly than that of the atmosphere, and is by no means subject to such extremes as the latter. It seldom exceeds 86° of Fahrenheit's thermometer. Within the tropic there is no sensible difference in north and in south latitudes; there is very little even as far as the thirty-fifth and fortieth degrees; but when we advance into high latitudes there can be no doubt that the sea is colder in the southern than in the northern hemisphere. The sea extends from five to eight degrees of latitude farther from the South than from the North Pole, owing, it is probable to the almost entire absence of land near the Antarctic circle.

The freezing of sea water is established both by observation and experiment;* the product, however, is an imperfect sort of ice, easily distinguishable from the result of a regular crystallization; it is porous, incompact, and imperfectly diaphanous. Saline ice may be formed by only five degrees less of cold than what is necessary to freeze fresh water. About the end of July, or the beginning of August, a sheet of ice, perhaps an inch thick, is formed in the space of a single night. The whale fishers enumerate several varieties of the salt water ice. A very wide expanse of it they call a *field*, and one of smaller dimensions, a *floe*. When a field is dissevered by a subaqueous or *grown* swell, it breaks into numerous pieces, seldom exceeding forty or fifty yards in diameter, which taken collectively are called a *track*.

The mountains of hard and perfect ice, called Icebergs, are the gradual production, perhaps, of many centuries. Along the western coast of Greenland, prolonged into Davis's Strait, they form an immense rampart, which presents to the mariner a sublime spectacle, resembling, at a distance, whole groups of churches, castles, or fleets, under full sail.†

* It was long disputed among the learned, whether waters of the ocean were capable of being congealed.

† See Discovery and Adventure in Polar Seas and Regions.—Harper's edition.

While Iceberges are thus the slow growth of ages, the fields or shoals of saline ice are annually formed and destroyed. It seldom floats during more than part of the year, unless surprised by the frost; when it is preserved till the following summer.

The thaw commonly lasts about three months; and during that time the heat of the solar rays, which though oblique, yet act with unceasing energy, whether applied directly or through the intervention of the air or the water, is sufficient for the dissolution of all the ice produced in the course of the autumn, winter and spring. The ocean is now unbound, and its icy dome broken up with tremendous rupture. The enormous fields of ice thus set afloat, are, by the violence of winds and currents, again dissevered and dispersed. Sometimes impelled in opposite directions they approach and strike with a mutual shock like the crush of worlds,—sufficient, if opposed, to reduce to atoms, in a moment, the proudest monuments of human power.

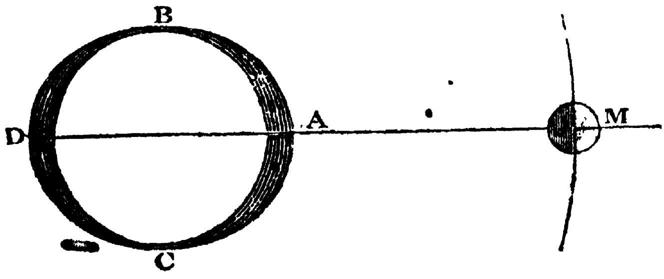
There are three kinds of movements constantly going on in the waters of the sea;—1. The agitations which its surface undergoes by the action of winds.—2. Tides, which are the result of the attraction exercised on the water by the sun and moon.—3. Currents, which arise from different causes, some of them existing within the element itself.

1st. As the particles of a fluid press equally in every direction, it follows that when a portion of the surface of the water is displaced by a wind, the adjoining water instantly rushes in to restore the equilibrium or balance which has been destroyed. This accounts for the formation of waves. When a violent impulse has thus been communicated, the waves continue in motion for some hours after the gale has entirely subsided, on the same principle as a pendulum continues to swing for some time after it has been set in action. Yet the agitation occasioned by winds extends comparatively but a little way below the surface of the water. Divers say that in the roughest weather, it is calm at the depth of 90 feet.

The tides are produced by the attraction of the moon. The cohesion of fluids being much less than that of solid bodies, they more easily yield to the power of gravity; in consequence of which, the waters immediately below the moon are drawn up in a protuberance, producing a full tide, or what is commonly called *high water*, at the spot where it happens. According to this theory, you would imagine that we should have full tide only once in twenty-four hours—that is, every time that we were below the moon—while we find that we have two tides in the course of twenty-four hours, and that it is high water with us and with our antipodes at the same time.

This opposite tide is rather more difficult to explain than that which is drawn up beneath the moon. In order to render the question more simple, let us suppose the earth to be every where covered by the ocean as in *fig.* 1. M. is the moon, A B C D the earth. Now the waters on the surface of the earth A, being more strongly attracted than in any other part, will be elevated, the attraction of the moon at B and C being less; but still it will be greater there than at D, which is the part most distant from the moon. The body of the earth will therefore be drawn away from the waters at D, leaving a protuberance similar to that at A; so that the tide A is produced by the water receding from the earth, and the tide D, by the earth receding from the water.

*Fig.* 1.



The influence of the sun on the tides is less than that of the moon; for, observe, that the tides rise in consequence of the moon attracting one part of the waters more forcibly than another part; it is this inequality of attraction which produces full and ebb tides. Now the distance of the sun is so great that the whole globe of the earth is comparatively but as a point, and the difference of its attraction for that part of the waters, most under its influence, and that part least subject to it, is but trifling; no part of the waters will be much elevated above, or much depressed below, their general surface, by its action. The sun has, however, a considerable effect on the tides, and increases or diminishes them as it acts in conjunction with, or in opposition to, the moon.

The moon is a month in going round the earth; twice during that time, therefore, at full and at change, she is in the same direction as the sun. Both then act in conjunction on the earth, and produce very great tides, called spring tides, as represented in fig. 2, at A and B; but when the moon is at the intermediate parts of her orbit, the sun, instead of affording assistance, weakens her power by acting in opposition to it; and smaller tides are produced, called *neap tides*, as represented in fig. 3.

*Fig.* 2.

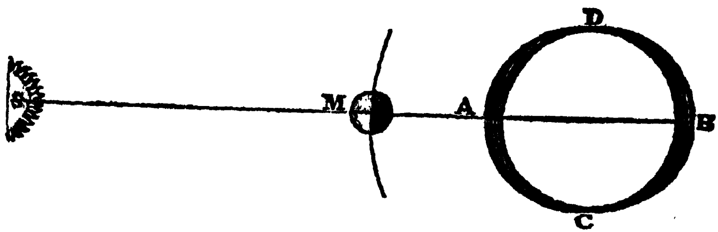
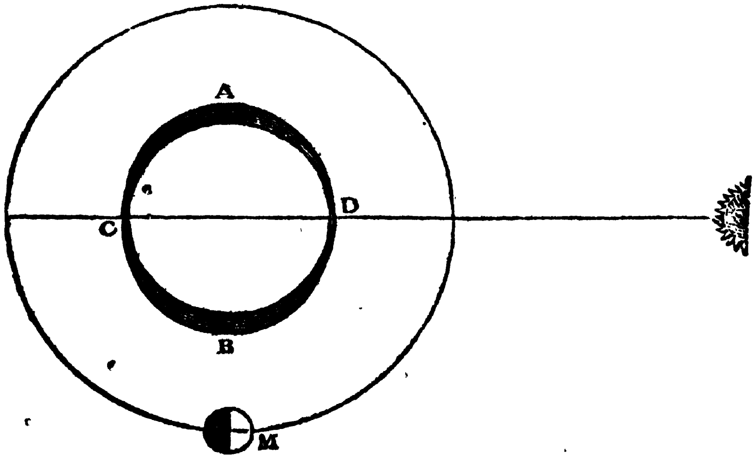


*Fig.* 3.




Since attraction is mutual between the moon and the earth, we produce tides in the moon; and these are more considerable in proportion as our planet is larger. Neither the moon nor the earth in reality assume an oval form, for the land which intersects the water destroys the regularity of the effect. The orbit of the moon being nearly parallel to that of the earth, she is never vertical but to the inhabitants of the torrid zone: in that climate, therefore, the tides are greatest, and they diminish as you recede from it and approach the poles; but in no part of the globe is the moon immediately above the spot where it is high tide. All matter, by its *inertia,* offers some resistance to a change of state; the waters, therefore, do not readily yield to the attraction of the moon, and the effect of her influence is not complete until some time after she has passed the meridian.

The earth revolves on its axis in about twenty-four hours: if the moon were stationary, therefore, the same part of our globe would every twenty-four hours, return beneath the moon; but as during our daily revolution

the moon advances in her orbit, the earth must make more than a complete rotation in order to bring the meridian opposite the moon: we are three quarters of an hour in overtaking her. The tides, therefore, are retarded, for the same reason that the moon rises later, by three quarters of an hour every day. This, however, is only the average amount of the retardation. The time of the highest tide is modified by the sun's attraction, and is between those of the tides which would be produced by the separate action of the two luminaries. The action of the sun, therefore, makes the interval different in different days, but leaves the average amount unaffected.

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## CURRENTS.

Currents and winds, especially the latter, have, according to their direction, an influence either in quickening or retarding the tide; indeed a powerful wind will sometimes keep a tide out of very narrow channels. On the contrary, a strong wind coming from the same quarter as the tide, will raise it several feet above its usual level. The causes which render the movements of the tide complex and irregular, may thus be summed up under four head;—1st. The variations in the positions of the sun and moon, with respect to the equator and to each other. 2d. The obstacles presented by the land. 3d. By winds; and 4th. By currents. The existence of these causes renders it impossible to lay down any general rule for calculating the level, either of high or of low water, in different latitudes.

*Currents* in the ocean may be occasioned in various ways; they may arise from external impulse, (a gale of wind for instance); from a difference in temperature or saltness between two parts of the sea, from the periodical melting of the polar ice, or from the inequality of the evaporation which the surface of the earth undergoes in different latitudes. These causes may produce either constant or occasional currents, and according as they act in concert or in opposition, will their effects be various.

The most remarkable currents are those which continually follow the same direction. There is one which sets regularly from each of the poles towards the equator; and when we get within twenty-eight or thirty degrees of the line on either side, a general movement is observed in the ocean, in direction nearly from east to west. The existence of the two polar currents is proved by the floating of masses of ice from the frigid into the temperate regions. These masses are at times, seen as low as the forty-fifth, or even the fortieth degree of latitude. It was the opposite of the polar current which principally occasioned the failure of the attempt made last year under Captain Parry to reach the north pole; before they desisted from their efforts, the expedition formed, that is, they advanced over the ice, they were being drifted southward, at a rate faster than that at which they were travelling northward. It is equally certain that a tropical current exists, judging not only from the direction of bodies floating on the water, but also from the circumstance, that vessels, in crossing from Europe to America, descend to the latitude of the Canary islands, where they fall into a current and are carried rapidly to the west. In going from America to Asia across the Pacific, a similar effect is observed. It might be supposed that this was one solely to the trade-winds but such is not the case, for it is quite possible to distinguish their effect from that of the currents, since the progess of the vessel is quicker than it could be with the aid of the wind alone.

The origin of the polar current is no doubt in a great measure to be referred to the centrifugal force which is the result of the earth's rotation. It may be further explained, when we reflect that the water towards the poles, both on account of its lower temperature and its being less attracted by the heavenly bodies is heavier than the water in the tropical regions, and moreover, that the heat of the torrid zone occasions a much more powerful evaporation of the sea than is elsewhere experienced; the consequence is, that the waters nearer the poles will move towards the equator in order to restore

the equilibrium which has in these several ways been destroyed. The tropical current may also, though in another manner, be explained as proceeding from the earth's rotation. The waters as they advance from the polar seas pass from regions where rotatory motion of the earth's surface is very slight to those where it is exceedingly rapid, they cannot immediately acquire the rapid motion with which the solid parts of the earth revolve in the tropical regions, and they are accordingly left rather behind, that is, to the westward, (the earth turning round from west to east.) The ocean consequently appears to retract from the western, and advance upon the eastern coasts of the continents, or in other words, to have a general movement from the east to west, and the effect is very much assisted by the constant blowing of the trade-winds.

We will now explain the modifications or changes which this grand movement in the ocean undergoes in consequence of the obstacles presented by the land to its free progress. When it meets with shores or narrow straits to impede or turn aside its course, it forms a strong and even dangerous current. The eastern coast of America and the West India Islands constitute a sort of dyke to the general westward motion of the Atlantic, and it will be seen, if we refer to a map, that from Cape St. Roche, which has about five degrees of south latitude, the coasts of South America stretches away in a continued line to the north west, as far as the isle of Trinidad. Owing to this shape of the Coast, the waters as far as the tenth degree of south latitude, are when they approach America, carried away in a current to the north west. This current afterwards enters the gulf of Mexico, through the strait formed by the western end of Cuba, and the opposite peninsula (from this part it is called by navigators Gulf Stream) and follows the bendings of the Mexican coast from Vera Cruz to the mouth of Rio del Norte, and then to the mouths of the Mississippi, and the shoals, west of the southern extremity of Florida. It next takes a new direction to the north, and rushes impetuously into the Gulf of Florida. Mr.

Humboldt observed in the month of May, 1804, in the 26th and 27th degrees of latitude, that its velocity was eighty-miles in twenty-four hours, although at the time there was a violent wind against it. At the end of the gulf of Florida (north latitude 28 degrees), it turns to the north-east, at the rate some times of five miles an hour. It may always be distinguished by the high temperature and the saltness of its waters, their indigo-blue colour, and the quantity of sea weed floating on the surface, and also by the heat of the surrounding atmosphere. The rapidity and temperature of the Gulf Stream diminish towards the north, while at the same time its breadth increases. Its further progress northward is at last checked by the southern extremity of the great bank of Newfoundland, in the forty-second degree of latitude, where it turns suddenly to the east. It afterwards continues moving towards the east and the east-south-east, as far as Azores islands, and thence it turns towards the straits of Gibraltar, the isle of Madeira, and the group of Canaries, till on reaching the parallel of Cape Blanco, it completes the round by mixing with the grand westerly currents of the tropics. It is probable, however, that a branch still keeps on its course to the south and south-east along the coast of Africa, for it is well known that ships if they approach too near the shore are drawn into the gulf of Guinea, and with difficulty get out again. We thus see that between the parallels of eleven and forty-three degrees, the waters of the Atlantic are carried on in a continual whirlpool. Humboldt remarks that supposing a particle of water to return to the same place from which it departed, we can estimate from our present knowledge of the swiftness of currents that this circuit of three thousand eight hundred leagues is not terminated in less than two years and ten months. A boat which may be supposed to receive no impulse from the winds would require thirteen months from the Canary Islands to reach the coast of Carracas, ten months to make the tour of the gulf of Mexico, and to reach Tortoise shoals, opposite the port of the Havannah, while forty or fifty days might be sufficient to carry it from

the straits of Florida to the bank of Newfoundland. It would be difficult to fix the rapidity of the retrograde current from this bank to the coast of Africa: estimating the mean velocity of the waters at 7 or 8 miles, in twenty-four hours, we find ten or eleven months for this last distance. It is a curious fact, that towards the close of the 15th century, before Europeans were acquainted with the existence of America, two bodies belonging to an unknown race of men were cast by the Gulf Stream on the coast of Azores, and pieces of bamboo were brought by the same current to the shore of the small island, Port Santo; by these circumstances, Columbus is said to have been strengthened in his conjectures with respect to the existence of a western continent.

An arm of the Gulf Stream in the forty-fifth and fifty degrees of latitude, runs to the north-east towards the coasts of Europe, aad becomes very strong when the wind has blown long from the west. The fruit of the trees which belong to the American torrid zone is deposited on the western coast of Ireland and Norway, and on the shores of Hebrides, are collected of several plants, the growth of Jamaica, Cuba, and the neighbouring continent. The most striking circumstance perhaps is that of the wreck of an English vessel, burnt near Jamaica having been found on the coast of Scotland. There are various currents in the Pacific and Indian oceans, the general westward motion of the former is impeded by a numerous Archipelago, and hence it receives different directions. A strong current sets to the west through each of the two straits which respectively separate New Holland from New Guinea, and from Van Dieman's Land. It then gets diverted, and flows northward along the coast of Sumatra till it reaches the bottom of the Bay of Bengal. The following appears to be the reason of its taking this course:—The general impetus of the Pacific towards the west being encountered by New Holland, and the numerous East India isles, is broken and dispersed, while the westerly motion of the Indian Sea has not in so early a stage acquired much strength; the polar current from the south at the same

time presses upon the wide opening which the Indian Sea presents to that quarter, and the waters on the eastern verge of that sea are therefore pushed into the Bay of Bengal. In the neighbourhood of Ceylon and Maldive islands, however, the tropical motion has become powerful enough to resist the polar current. The westerly current then re-commences, but is again turned out of its line and made to flow to the south-west by the chain of islands and shallows which reaches from the extremity of the Indian peninsula to Madagascar. After passing Madagascar it dashes against Africa, and at the termination of that continent, mingles with the general motion of the waters.

A current afterwards sweeps from the Atlantic into the Pacific ocean through the strait of Magellan. There can be little doubt that this is a branch of the general current from the south pole, though at the same time it may be partly the result of the westerly movement of the Atlantic, which being checked by the shores of Brazil, flows to the south-west, along the South American coast.

There is a question connected with the currents of the Arctic ocean which has engaged a good deal of attention and been considered difficult to explain: it is from what quarters the timber can come, which is found floating on the polar seas in such large quantities, and so much of which is thrown ashore on the northern side of Iceland. The few specimens seen of the growth of Mexico and Brazil must have travelled to the North by means of the Gulf Stream, of which we have spoken; the rest (principally pines and firs,) most likely come from Siberia and North America, along the shores of which it is drifted till it arrives at the opening in the Atlantic, in the midst of which Iceland is placed.

The existence of under currents, different from, and even opposite in their direction, to those on the surface, is by no means improbable in some cases, though it is a matter not admitting of proof. It has been thought that the Mediterranean which has a strong flow always setting into it through the strait of Gibraltar sends back a por-

tion of its waters into the Atlantic by a concealed current. Contrary currents passing along side-by-side are not uncommon. In the Kattegat a northern current flows out of the Baltic, along the coast of Sweden, while a southern one enters the Baltic along the coast of Denmark. When two opposite currents of about equal force meet one another, they sometimes, especially in narrow channels, turn upon a centre and assume a spiral form, giving rise to eddies or whirlpools. The most celebrated of these are, the Euripus, near the island of Eubœa, in the Grecian Archipelago, Charybdis, in the strait between Italy and Sicily, and the Maelstorm, off the coast of Norway. The most violent of them when agitated by tides or winds become very dangerous to navigation.

## Section II.

### *Of Lakes, Rivers, and Springs.*

### LAKES.

Collections of water, on all sides surrounded by land, and having therefore no immediate connection with the sea, are denominated *lakes*. We distinguish three kinds, 1st. Those which neither receive any running water, nor have any efflux or discharge. Such are usually small, and do not merit much attention. 2d. Those which both receive running water and have an efflux. These are either the product of a multiplicity of springs, so small or so deep in the earth as to escape notice, or are visibly occasioned by the accumulation of waters brought down by rivers into capacious valleys or basons. Some of the latter are immensely large, and merit the title of seas, as the lakes or sea of Canada, in North America. 3d. Those, which, though they receive rivers, like the preceding class, yet have no perceptible efflux; of which there are several examples in Asia, and particularly the Caspian Sea, as its magnitude warrants it to be styled. These lakes are generally very extensive, and so situated as to be much exposed to the solar rays

and the constant action of considerable winds, so favorable to evaporation, which, together with the nature of the adjoining soil, permitting a large portion of water to be imbibed, may readily account for their retaining the same level and magnitude, notwithstanding the perpetual supply from rivers.

The temperature, depth, extent of water, &c., of lakes, are various, and necessarily connected with many local circumstances.

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## RIVERS.

The union of springs, rills, brooks, &c., having their chief origin in the aqueous precipitations from the atmosphere, constitutes *rivers*, by which the overplus waters of the land are finally restored to the great receptacle of the ocean. Rivers usually arise in elevated countries, in the descent from which, they acquire a velocity that is generally sufficient to carry them over any plains or through any hollow places met with in their course. This velocity, however, is seldom retained towards the end, being diminished by the continual friction of the waters on their channels, and the variety of obstacles encountered. But even when entirely spent, there may remain enough of force in the perpendicular pressure of the water itself, to effect the necessary evacuation, except in a few cases where the waters are lost in the sand at the termination, or dissipated in a vapour. The greatest velocity of a river is usually observed about the middle of its depth and breadth, and the least towards the bottom and sides.

The *course* or *run* of rivers is of extremely variable length, extending from a few to some thousand miles. It is determined by several circumstances, as the distance of the source from the sea;—the nature and arrangement of the country traversed,—the number and magnitude, of tributary streams,—the peculiarities of the climate, with respect to temperature and seasons, &c.

The *beds* or *channels* of rivers are partly owing to those revolutions which have altered the face of the

earth, and partly to the natural action of the rivers themselves. To the former cause, it seems reasonable to ascribe the remarkable examples of rocks and large beds of compact strata penetrated by rivers, whose velocity and force are far from being considerable. The latter operation may be expected to occur in a loose and soft soil, which readily gives way to a gentle pressure of long continuance. Great alterations are made in the sides and bottoms of the beds; in course of time, some parts being much depressed or worn down by the force of the current; and others again, are elevated, by the gradual deposition of mud and other product of the soil, brought down from a distance. Hence it happens that the entire course of a river is sometimes changed, and more especially towards its termination or mouth. When rivers traverse rocky countries of a hilly nature, and of various levels, they are observed to form *leaps* or *cataracts*, which are a kind of violent transition from a higher to a lower bed. In place of these are sometimes found very narrow passes, where the water is so greatly compressed as to have acquired an immense increase of velocity.

All rivers subject to occasional *swells* or *floods*, owing to the large addition of waters made by heavy rains in the upper parts of their course. These are sometimes periodic, and to a great extent, so as to overflow large tracts of country. This was long imagined to be peculiar to the Nile, but many other large rivers, particularly within or dependent on tropical countries, exhibit a similar phenomenon.

The *mouths*, or exits of rivers are various in appearance. In some cases, the waters glide smoothly down into the sea, mixing almost immediately with its waves. In others, the forces of the rivers and its volume are so considerable, as to preserve a well marked distinction between the two elements, at a great distance from the place in which they meet. A third kind, again, forms bars of sand, of more or less extent, through which the water seems to find a way of escape into the ocean. While, in a fourth example, the marine tides, for a time,

resist the passage of the river, occasioning a retardation and accumulation of waters which overtop its banks and deluge the neighbouring country.

In comparing the size of different rivers and the mass of water which they contain, it would be necessary to take into account the length of their course, their breadth and depth, as well as their velocity at various parts. This is obviously a difficulty, and it may be added, hitherto, an almost unattempted task. It is easy enough on the whole, to compare many of them together, in one particular, that is, as their length, and breadth, and depth, &c., separately; but all these require to be combined, in order to exhibit their relative magnitudes and proportions. Major Rennell, in his Memoir of Hindustan, has given a list of the relative lengths of rivers, the Thames being reckoned as unity; but it does not exactly correspond with the existing amount of information on the subject.

## SPRINGS.

The origin of *springs*, from which rivers have their source, is a problem that has long exercised and divided naturalists. It seems improper to confine it to one cause, however powerful, springs, differing so much in situation, extent, and quality, as to require the operation of various agents. Of these may be enumerated the precipitation of atmospherical, and the ascent of subterraneous vapours, infiltration of marine water, and the liquefaction of ice and snow. Springs are either perennial or temporary, intermitting or reciprocating. Personal springs are such as flow continually, and with little or no change of magnitude. These can hardly depend altogether on so precarious a supply of rain water. Temporary springs flow only during certain seasons of the year, and in all probability, are the product of the source now mentioned. Intermitting springs flow and stop alternately, in consequence, it is presumed, of their connection with the sea. Reciprocating springs flow constantly, but in a variable manner as to quantity, not well explained. Springs

which have their waters combined with *mineral* substances, and are, from that circumstance, called *mineral*, are very numerous, and of various kinds. *Warm* and *hot* springs are also common, especially in volcanic countries, where they are sometimes distinguished by violent ebullitions. Iceland is noted for these curious phenomena; its celebrated boiling fountain, the great Guysee, frequently throws out its contents to the height of more than a hundred feet, sometimes to twice that elevation.

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## SECTION III.

Of Clouds.—Vapors.—Fogs.—Mists.—Dew.—Hoar Frost.—Rain.—Snow.—Hail.

The clouds are considered the product of vapours exhaled from the sea and land, and which have combined together by some, hitherto, not perfectly ascertained laws. They are rarely formed in the lower strata of the atmosphere, the vapours from which they proceed, ascending by their less specific gravity to the higher regions, where the combination takes place. Clouds are not often suspended more than a mile above the surface of the earth; and consequently, a person at a great height, as on the top of a lofty mountain, generally sees the clouds below him. They are all more or less electrified, and those which are most so, commonly descent to the lowest. Hence, thunder-clouds, as they are called, repair at times to touch the earth with one of their edges or a tail, and actually indeed, come so near as to permit a communication by means of vapour or rain, when the fire immediately takes place with an electrical discharge. The motions of the clouds are in general directed by the wind, but in some cases depend altogether on their electrical condition. Contrary currents, in different strata of air, often compel the clouds to pass each other without any combination or collision. Different degrees of velocity in different strata, produce corresponding effects on the motion of the clouds. It sometimes happens, that clouds actually meeting and touching each other, in

place of forming a large one, vanish entirely away, which is to be ascribed to the discharge of opposite electricities existing in them. The various figures of the clouds are partly owing to their loose and easily mobile texture, and partly to their electricity. The formation of strange shapes, and the vanishing of small clouds on contact, are indications of thunder, in the proper or usual seasons of its occurrence. The colours of the clouds depend on their situation with respect to the sun, and their aptitude to reflect and refract his rays. Those of most frequent appearance are brown, grey, red, yellow and white, of all shades. A green cloud is a highly beautiful, but very rare occurrence. The blue colour of the sky is to be imputed to the vapours invisibly mixed with air, having the property of reflecting the blue ray of light more copiously than any other.

The vapours arising from moist places, or the surface of the ground after rain, &c. sometimes collect together in the lower strata of air, and form fogs and mists which partake of some of the properties and nature of clouds. A particular kind of dry fogs has been noticed to proceed some earthquakes and volcanic eruptions.

The nature and constitution of *dew* are not yet thoroughly understood, but have of late years attracted very minute inquiry. Its origin may be traced, like that of rain, to evaporation, but not exactly from the same cause. In the case of dew, the heat which gives rise to the formation of vapour derived from the earth, which, being denser than the air, retains it long after the sun has set.

This, therefore, being communicated to the moisture on the surface, occasions an ascent of vapour either in a visible or an invisible state. The vapour so raised, at last meets with a colder medium, which condenses and combines it, and thus, by increasing its density, causes its return to the ground. Dew, therefore, may be said, both to ascend and descend, which accounts for a number of curious circumstances observable of it. But the operation of electricity is undoubtedly concerned in some of the phenomena of dew, more especially its apparent

preference for certain substances, and aversion to others. Dews are often combined with various matters, which may be either salutary or injurious to animal and vegetable life. When dew freezes from the coldness of the atmosphere, or the disappearance of sensible heat, it assumes the form and obtains the name of *hoar frost.*

The precipitation of vapour in the form of drops constitutes *rain;* its formation is to be reckoned among the electrical phenomena, no known law of any of the other agents being quite sufficient to explain it. The quantity of rain that falls in different countries is immensely various. The mean annual quantity is greatest at the equator, and decrease towards the poles, and hence is presumed to be influenced by the heat of the climate. But it is materially influenced also by many local circumstance. Thus a greater quantity is found near the sea coasts than in inland countries, and in the vicinity of lofty mountains than in plains; again, those winds bring most rain which blow from large seas; and, on a small scale at least, all other circumstances being alike, a difference of elevation above the ground, occasions a difference in the amount of rain, a larger quantity falling on the lowest place. The quantity is greater in summer than in winter, though there be fewer rainy days in the former, which in this respect resembles the equatorial regions, where rain is the heaviest, but the least frequent. The countries where thunder is hardly known, little or no rain is observed, as in Egypt and the plains of Peru. The mean annual quantity of rain of Great Britain has been estimated at 32½ inches in depth, that which falls on the whole globe has been reckoned at 34 inches, and amounts therefore to 91,751 cubic miles of water; but this, immense as it seems, is judged to be less than the average quantity of water evaporated from the earth, in the proportion of 41 to 44, and hence a sufficient source may remain for the supply of the other atmospheric motions, into which water, in its natural or decomposed state, is known to enter. Snow and hail are modifications of rain, occasioned by the deposition and transmission of vapour in different states of aggrega-

tion, through zones or strata of the atmosphere at low temperatures.

Several remarkable kinds of rain and snow which have sometimes been observed, were formerly imagined to be preternatural, but appear to admit of explanation consistently with known laws. It is enough merely to mention rains of blood, of sulphur, of fire, red snow, &c., which, however calculated to astonish and dismay the vulgar, to whom every thing unusual is miraculous, present little difficulty in the way of philosophical investigation. In reality, occurrences of this kind, which seem the least susceptible of exposition, are often much more easily accounted for, than those ordinary phenomena, which, from their being daily presented to us, are conceived to be perfectly well understood of all the aqueous meteors, it is curious, but not ill-timed, to observe, the utility is well ascertained, with the exception of hail, which, though capable of perhaps more mischief than any of them, has not yet been discovered conducive to any one beneficial purpose.

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## Section IV.

**Of Thunder and Lightning.—Falling Stars.—Ignis Fatuus —Aurora Borealis and Rainbow.**

Of all the atmospherical phenomena there are none more awfully sublime than those of thunder and lightning. Respecting the nature and cause of these it would be useless to cite the opinions of ancient philosophers, as all our real knowledge on these subjects is derived from modern discoveries, and particularly those in electricity. Dr. Franklin ascertained the identity of lightning and electricity; since then, the attention of philosophers has been directed to the inquiries, how the electric fluid or energy circulates from the earth to the air and back again to the earth, by what means it is raised into the atmosphere, how it becomes redundant, and how it is returned to the earth again. The aqueous vapour, or steam of the atmosphere appears to be the vehicle. The dry and permanent

elastic fluids have probably no more to do than as non-conductors of electricity, to obstruct its passage through the atmosphere. When water is evaporated it takes along with it a greater quantity of electricity, as well as heat, than it had before; that is, the capacity of vapour for electricity is greater than that of water. This fact has been observed by most of those who have of late years, carefully attended to electrical phenomena. Of course, when the steam is condensed into water, there must be a redundance of electricity as well as of heat; and if the air be a non-conductor, (as it undoubtedly is, when dry), the drops of water or the cloud formed, must be electrified positively. This is ascertained to be the fact. If, during a thunder storm, and on some few other occasions; the atmosphere exhibits signs of negative electricity, it can scarcely be doubted that this is occasioned by the action of some superior cloud, which being positively electrified, makes the other, or the circumambient air negative by indication, agreeably to the well-known law of electricity. The reason why the atmosphere cannot be negatively electrified is, that in the ordinary course of nature, *no evaporation of water, insulated by the atmosphere, can ever take place;* the evaporation being always originally from the earth's surface.

Conformably to these observations then, we may lay it down as an established maxim, *that the electricity of every cloud at its formation, is positive.* It will remain there to be explained how the phenomena of thunder and lightning are to be accounted for on this position. One most obvious question occurs of the electricity of one cloud to find it expedient to force its way to the earth by a violent discharge; why is it not universally the case, and why are not thunder and lightning as frequent as clouds and rain?

Before this question can be satisfactorily answered, we must make ourselves acquainted with the circumstances that usually accompany thunder and lightning. It will be generally allowed that the frequency of thunder and lightning in this part of the world at least, (England), is in proportion to the quantity of aqueous vapour in the

atmosphere, or, which nearly amounts to the same thing, to the temperature of the air. The following extract from Dalton's Meteorology being the result of five year's observations, well support this assertion.

| | Jan. | Feb. | Mar. | April | May | June |
|---|---|---|---|---|---|---|
| Mean temperature each month.... | 37° | 39° | 39° | 45° | 51° | 56° |
| Number of days when thunder was heard..................... | 1 | 0 | 0 | 3 | 7 | 5 |

| July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|
| 57° | 58° | 53° | 46° | 41° | 35° |
| 12 | 7 | 7 | 2 | 0 | 1 |

In fact, thunder is very rare in winter, perhaps never known in frost, more frequent in spring and autumn; but, it is in the months of May, June, July, August, and September, which are the warmest months in the year, that we usually expect, and have to record thunder-storms of any consequence or duration. It is further remarkable that when thunder is observed in winter, it is always during a low barometer, and an unusually warm vapoury state in the atmosphere. Whenever vapour is precipitated from the atmosphere by the causes we have mentioned, the quantity will be greater in proportion, as the absolute quantity of aqueous vapour in the atmosphere is greater. This arises from the increase of vapour being in a geometrical progression to that of temperature in arithmetical progression. Rain, with the dew point at 60° will be twice as heavy, all other circumstances the same, as rain with the dew point at 40°; because there is twice as much steam in the air in the former case. It has already been observed, that the clouds are higher or more elevated above the surface of the earth in summer than in winter. From combining these observations, we may, perhaps, obtain a satisfactory reason for thunder not accompanying every cloud and shower of rain. In winter the clouds are low, less dense, and consequently less electric, than in summer; their electricity silently and slowly steals away to the earth's surface. In summer, the intensity of the electricity is double, in consequence of its quantity being as the vapour condensed, and it is more removed from the earth or insulated by its superior altitude; hence its energy may be

so far increased as to overcome the resistance of the air. Thus, if an imperfectly rounded ball of metal be presented at a proper distance from the conductor of an electrical machine, it will slowly and silently draw off the electricity; but if the intensity of the electricity be increased sufficiently, nearly the whole will come away in an instant in the shape of a dense spark, with a snapping noise.

Thunder-storms generally happen when there is little or no wind; and their first appearence is marked by one dense cloud, or more, increasing very fast in size, and rising into the higher regions of the air; the lower surface black, and nearly level, but the upper finely arched, and well defined. Many of these clouds seem frequently piled one upon another; all arched in the same manner; but they keep continually uniting, swelling and extending their arches.

At the time of the rising of this cloud, the atmosphere is generally full of a great number of separate clouds, motionless, and of odd and whimsical shapes. All these, upon the appearance of the thunder cloud, begin to move towards it, and become more uniform in their shapes as they approach; till, coming very near the thunder cloud, they mutually stretch towards one another, immediately coalesce, and together make one uniform mass. But sometimes the thunder cloud will swell, and increase very fast, without the conjunction of these adventitious, clouds, the vapours of the atmosphere forming themselves into clouds whenever it passes. Some of the adventitious clouds appear like white fringes at the skirts of the thunder cloud, but these are continually growing darker and darker, as they approach or unite with it.

When the thunder cloud is grown to a great size, its lower surface is often ragged, particular parts being detached towards the earth, but still connected with the rest. Sometimes the lower surface swells into various large protuberances, bending uniformly towards the earth. When the eye is under the thunder cloud, after it is grown larger, and well formed, it is seen to sink lower and to darken prodigiously; at the same time,

that a number of adventitious clouds (the origin of which can never be perceived), are seen in rapid motion, driving about in every direction under it. While these clouds are agitated with the most rapid motions, the rain generally falls in the greatest plenty; and if the agitation is exceedingly great, it commonly hails.

While the thunder cloud is swelling, and extending its branches over a large tract of country, the lightning is seen to dart from one part of it to another, and often to illuminate its whole mass. When the cloud has acquired a sufficient extent, the lightning strikes between the cloud and the earth, in two opposite places, the path of the lightning lying through the whole body of the cloud and its branches.

The electrical explosion generally takes place in the air, and at a considerable height; but in many instances it happens between the clouds and the earth. In most instances, the lightning descends from the clouds to the earth, and the explosion is then called the descending stroke; but in some cases, it is known to pass from the earth to the clouds, and is then termed, the ascending stroke: of the latter kind, appears to have been the explosion which took place on the Malvern Hills, in the summer of 1826, and which was attended with such melancholy consequences. A very curious instance of the ascending stroke is related by G. F. Richter, in his work on thunder. He informs us, that in the cellar belonging to the Benedictine Monks of Fontigno, while the servants were employed in pouring into a cask some wine which had been just boiled, a fine light flame appeared round the funnel, and they had scarcely finished their operation when a noise like thunder was heard; the cellar was instantly filled with fire; the cask was burst open although hooped with iron; the staves were thrown with prodigious violence against the wall; and on examination, a hole of three inches in diameter was found in the bottom of the cask.

The following precautionary hints may be offered, as they comprise the best modes of ensuring safety during a thunder-storm.

Shelter should not be taken under trees or hedges, for, should they be struck, such situations are particularly dangerous; at the time a person is much safer at about thirty or forty feet from such objects than at a greater distance, as they are likely to operate as conductors. Large portions of water also ought to be carefully avoided, and even smaller streams that may have resulted from recent rain, as these are good conductors, and the height of a human being connected with them, may sometimes determine the course of the lightning. In a house, the safest situation is considered to be the middle of the room; and this situation may be rendered still more secure by standing on a glass-legged stool; but as such an article is not in the possession of many people, a hair mattress, or a thick woollen hearth rug makes a very good substitute. It is very injudicious to take refuge as some persons do, in the cellar or place below the surface of the earth, during a thunder-storm, since the discharge is often found to be from the earth to the clouds, and many instances are recorded of buildings that were struck having sustained the greatest injury about the basement story. But whatever situation is chosen, the greatest care should be taken to avoid any approach to tall trees or buildings or metallic rods since they are powerful conductors.

The distance of the thunder-cloud may readily be determined, as the interval between the flash and the commencement of the report furnishes the data necessary for the calculation. According to Flamstead, sound travels at the rate of 1142 feet in a second; consequently by a watch which points the seconds, the distance of the cloud is easily ascertained, for the flash and the sound are really contemporaneous; and the former requires hardly any perceptible lapse of time to travel through any ordinary distance. Thus, for example, suppose the flash to occur five seconds before the sound is heard, then $1142 \times 5 = 5710 =$ 1 mile 430 feet, the distance of the explosion from the place of the observer. So far this calculation is very gratifying, but it is no criterion of safety, for it only indicates the distance of a discharge

that has taken place; the next may render the observer incapable of observation.

Shooting or falling stars, as they are called, are caused by streams of the electric fluid passing rapidly through the higher regions of the air; and these phenomena of which we are now speaking, are, on all probability, portions of the same matter passing through regions of the high air which are comparatively at small altitudes.

These meteors vary considerably in size and colour, and also in the rapidity of their motion; they move in various directions, but chiefly incline towards the earth. They occur in different states of the atmosphere, but prevail most in clear frosty nights, and at other times, when the winds are easterly, and the sky clear; in the intervals also of showery weather they are frequent, and on summer evenings, when well defined clouds are seen floating in a clear atmosphere.

The *ignis fatuus*, or, *will with the wisp*, that appears so often in boggy, marshy, and damp situations, decoying the unwary traveller, and terrifying the superstitious traveller, seems to be rather of a phosphoric than an electric nature, similar to the light which is emitted by stale fish or fire flies. Sir Isaac Newton defined it to be a vapour shining without heat

A remarkable ignis fatuus was observed by Mr. Derham in some boggy ground, between two rocky hills. He was so fortunate as to be able to approach it within two or three yards. It moved with a brisk and desultory motion about a dead thistle, till a slight agitation of the air, occasioned, as he supposed, by his near approach to it, occasioned it to jump to another place; and as he approached it, it kept flying before him. He was near enough to satisfy himself that it would not be the shining of glow-worms or other insects—it was one uniform body of light.

All the luminous appearances are probably owing to the extrication of hydrogen gas, so slightly impregnated with phosphorus as to continue emitting a faint lgiht,

without producing that brilliant flash which follows the sudden extrication into the air of the common phosphorated hydrogen gas, obtained in the usual chemical experiment of throwing phosphuret of lime into water.

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The *aurora borealis*, or northern lights, are generally considered to arise from the passage of electricity through highly rarefied air, and the mode of producing these different luminous streams has already been adverted to.

Mr. Dalton gives the following accounts of this splendid phenomenon. " Attention was first excited by a remarkably red appearance of the clouds to the south, which afforded sufficient light to read by, at eight o'clock in the evening, though there was no moon, nor light in the north. Some remarkable appearance being expected, a theodolite was placed to observe its altitude, bearing, &c. " From half past nine to ten o'clock P. M., there was a large, luminous, horizontal arch to the southward, almost exactly like those which we see in the north, and there were some faint concentric arches northward. It was particularly noticed that all the arches seemed exactly bisected by the plane of the magnetic meridian. At half past ten o'clock, streamers appeared very low in the south-east; they increased in number and began to approach the zenith apparently with an accelerated velocity; when all on a sudden, the whole hemisphere was covered with them, and exhibited such an appearance as surpasses all description. The intensity of the light, the prodigious number and volatility of the beams, the grand intermixture of all the prismatic colours in their utmost splendour, variegating the glowing canopy with the most luxuriant and enchanting scenery, afforded an awful, but at the same time, a most pleasing and sublime spectacle. Every one gazed with astonishment; but the uncommon grandeur of the scene only lasted about one minute; the variety of colours disappeared, and the beams lost their lateral motion, and even converted into the usual flashing radiations; but even then, it surpassed all other appearances of the aurora, in that the whole hemisphere was covered with it.

The aurora borealis, or, as the same appearance is commonly termed *streamers*, and in the Shetland Isles, the *merry dancers*, can seldom be seen in the southern parts of the kingdom; and, even when seen there, the appearance is far less brilliant than in northern latitudes, where this wonderful phenomenon is the *constant attendant* of clear evenings, affording a great relief to the inhabitants, amid the gloom that would otherwise attend their dreary wintry nights.

Now, between these appearances and those of electricity, under certain circumstances, there are several points of close resemblance. For it is found by a simple experiment that when the electric fluid is made to pass through rarefied air, it exhibits a diffused luminous stream which has all the characteristic appearances of the northern lights. There are to be seen the same varieties of colour and intensity, the same undulating motion and occasional corruscations; the stream exhibits the same diversity of character. At one moment minutely divided into ramifications, and at another, beaming forth in one body of light, or passing in well defined flashes; and, when the rarefaction is high, various parts of the stream assume that peculiar glowing colour which occasionally appears, and which, on the whole, leaves but little room to doubt that the phenomenon is produced by the passage of electricity through the upper regions of the atmosphere.

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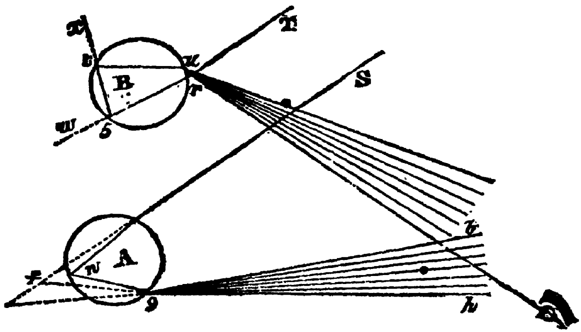
Of all the natural phenomena, the *rainbow* is one of the most beautiful. This meteor, which in poetical language is called the *iris*, never makes its appearance, except when the spectator is situated between the sun and a shower of rain; and that this conclusion is just, any one may satisfy himself by the following experiment;—fill a hollow glass globe with water, and suspend it in the sun, in such a manner that it may be raised or lowered at pleasure; at a certain height above the eye of the spectator, who looks at it with his back to the sun, the globe will appear to be red; let it then be slowly lowered, and it will appear to be orange, and afterwards in succession, as it descends, it wlll appear yellow, green,

blue, indigo and violet. Hence, the same drop of rain which must be considered as a little globe, supplies all the seven colours to the eye. There are sometimes two rainbows seen at the same time, one within the other, and what may seem remarkable, the order of the colours of the exterior bow is the reverse of that of the interior one. When two bows are seen, the exterior one is comparatively faint, and, it is therefore sometimes called the false or secondary bow; while the greater distinctness of the interior one has obtained for it the appellation of the primary bow. To trace the progress of a ray of light through a drop of rain in each of these bows, will explain the cause of their differing in brightness. In the true or primary bow, the rays of light arrive at the spectators eye after two refractions and one reflec-




Thus, let A, in the above diagram, be a drop of rain, and *s* a ray from the sun falling on the upper part of the drop It will suffer a refraction, and instead of going

* The rainbow was one of those phenomena which astonished and perplexed the ancients; and after many absurd and unsuccessful conjectures, their best philosophers, Pliny and Plutarch, relinquished the inquiry, as one, which was above the reach of human investigation. In the year 1811, Antonio de Dominio made a considerable advance, however, towards the theory of the rainbow, by suspending a glass globe in the sun's light, when he found that, while he stood with his back to the sun, the colours of the rainbow were reflected to his eye in succession by the globe, as it was moved higher or lower. He was, however, unable to account for the production of the different colours, as the experiments with the prism had not yet been made, and it was reserved for Newton to perfect that discovery.

forward in a right line it will be bent to *n*; at *n*, part of it will emerge, but the remainder will be reflected to *g*; at *g*, it will be again refracted on passing into the air towards the eye at *h*; being thus twice refracted and once reflected, the ray is separated into its primitive colours; the red part, which is least known out of its course, makes an angle, at its emergence, with the incident solar ray of forty degrees two minutes, as *s*, *f*, *h*; and the violet, being the most easily thrown out of its course, makes with the solar light an angle of forty degrees, seventeen minutes. The different colours, therefore, at the distance of the spectator, are considerably separated, and affect the eye in succession with the seven colours; but the succession is so quick, and so many drops fall through the same circuit in the same time, that the mind loses the idea of succession, and the point seems permanent as long as the shower continues in a proper direction for the eye.

The exterior or secondary bow is formed by two reflections and two refractions. Let B represent one of the drops of rain forming this bow; a ray, T, from the sun, falling upon it at *r*, is refracted, and falls upon the back of the drop at *s*; from the transparency of the drop a portion of it passes through towards *w*, but the remainder of it is reflected towards *t*; here again, for the same reason as before, part of it emerges from the drop, in the direction *x*, but the portion still left is reflected to *u*, where it is refracted towards the spectator with the red rays uppermost.

The great quantity of light lost at each reflection is the cause of the indistinctness of the bow, and therefore we cannot be surprised that we rarely, if ever, see bows formed by a still greater number of reflections within the drops; for though they may exist, they are too faint to be seen. The secondary bow connot be seen when the elevation of the sun is about fifty-four degrees seven minutes, and it is broader than the interior bow, because the rays are more dispersed before they reach the eye.

## SECTION V.

On the changes that take place on the Earth's Surface.—Action of Running Waters.—Breaking down of Coasts.—Encroachment of Sands.

From the quiet and regular succession of natural events to which we are accustomed, and the repugnance which we feel to the idea that it is possible for the course of nature to suffer interruption, we might without due investigation almost persuade ourselves that the physical features and conditions of the globe possess an unchangeable character. So far, however, is this from being the case, that there is no country wherein traces are not discoverable of the great changes and violent revolutions of which the earth has formerly been the theatre. The confusion often exhibited in the position of the different strata or layers of which the crust of the earth is composed, the frequent discovery of the remains of animals, vegetables deeply buried in the soil, and many other appearances, testify that the surface of the globe has undergone convulsions, to the production of which none of the natural agents with which we are acquainted can be regarded as adequate; unless they once acted in a method, and with an extent of violence of which it is impossible for us, by reference to what now exists, to form a conception; the lowest and most level parts of the earth exhibit nothing, even when penetrated to a very great depth, but horizontal strata, composed of substances more or less varied, and containing almost all of them innumerable marine productions. Similar strata, with the same kind of productions, composed the lesser hills to a considerable height. Sometimes the shells are so numerous as to constitute of themselves the entire mass of the rock; they rise to elevations superior to the level of every part of the ocean, and as found in places where no sea could have carried them at the present day, under any circumstances, they are not only enveloped in loose sand, but are often enclosed in the hardest rocks. Every part of the earth, every continent,

every island, of any extent exhibits the same phenomenon."—(Cuvier's Essay on the Theory of the Earth.) The perfect state in which these shells are generally found, and the regularity, thickness and extent of the beds that contain them, prove that they could not have been deposited in their places by any temporary invasion of the sea, but that the water must have remained there long enough in a state of tranquility, to have allowed them gradually to deposit themselves. Some of the strata of marine formation are much more recent than others; while in the midst, even the oldest strata of this kind, other strata appear full of animal or vegetable remains of land or fresh water production. On these accounts it would seem as if the land, now inhabited by man, had experienced various successive eruptions and retreats of the sea. There are also appearances which lead to the conclusion, that the catastrophes which have occasioned these changes have been sudden and violent. To numberless living beings they were the messengers of destruction; and of many, the very races have been utterly extinguished. Cuvier, the celebrated French geologist and natural historian, from an observation of the fossil bones of more than one hundred and fifty quadrupeds, has determined that upwards of ninety of these animals were of kinds unknown to naturalists. There can be no doubt, that the revolutions in which these animals were destroyed, occasioned great changes in the climate in many parts of the earth, and that in some instances, at any rate, the change took place very rapidly. Fossil plants, and animals of similar kinds which still exist in warm regions, have been found in countries where the cold is very much beyond what such kinds are capable of sustaining; and in the arctic zone, the carcases of large quadrupeds have been discovered enveloped in the ice with their skin, hair, and flesh, still remaining so, that the alteration in the climate must have occurred with such suddenness as to prevent their bodies from being decomposed by putrefaction. Such are some of the traces that bear witness to the revolutions which the surface of the globe has undergone.

These wonderful and destructive events, of the immediate causes of which nothing can be declared with certainty, must have long ceased; but the earth has since experienced, and is still experiencing, changes of a very perceptible kind which we shall now proceed to notice.

Of the several agents which contribute to these changes, water has the widest sphere of activity. In all, abrupt and precipitous mountains, fragments of earth and rock are continually falling down from the higher parts, owing to the slow, but effectual action of rains, storms, &c., and these become rounded by rolling upon each other, these fragments collect upon the sides and at the foot of the mountains, and, on some occasions, when undermined by rivulets, have been known to slip down in immense masses, and by stopping up the course of rivers, create great devastation. But, without any such extraordinary occurrences as these, the streams that descend along the flanks of elevated grounds carry along with them some portion of the materials of their respective slopes, especially when swelled into violence by rains or the melting of snows; and such as come from mountains sweep down with them even some of the fragments of rocks that have been collected in the high valleys. In proportion, however, as these streams reach the more level country and their channels become more expanded, they deposit the fragments and stones, till at last their waters convey along only particles of mud of the minutest kind. If, therefore, these waters do not run too rapidly into the sea, or the particles in question, do not previously settle in some lake through which the rivers pass, the mud is deposited at the sides of their mouths forming low grounds, by which the sources are prolonged and encroach upon the sea; and which the waves by casting up sand upon them, assist in their increase, whole provinces are created, capable from their soil, of yielding, in the highest degree, to the support of man, and of being made the seats of wealth and civilization. It has been concluded with reason, that the greater part of Lower Egypt owes its formation to the alluvial matter brought down by the Nile, aided by the

sand cast up by the sea. M. Dolomica has endeavoured to show that the tongue of land on which Alexandria was built, (three hundred thirty-one years before Christ,) did not exist in the days of Homer; (about 900 B. C.,) and that the lake Mariotes was at the latter period, a large gulf of the sea in the time of Strabo, the geographer, who lived about the commencement of the Christian era, this gulf had been enclosed by land, and is described as a lake of six leagues in length. More certainly exists as to the changes that have occurred since that period. The sand thrown up by the sea, and wind has formed, near the site of the ancient town, a narrow tongue, on which the modern Alexandria stands. It has blocked up the nearest mouth of the Nile, and reduced the lake Mariotes almost to nothing; while the rest of the shore has been very much extended by the continual deposition of alluvial matter. In the time of the ancients, the Canopian and Pelusian were the principal mouths of the Nile and the coast ran in a straight line from the one to the other. The water now passes out chiefly through the Bolbitian and Phatnitic mouths; and round them the greatest depositions have taken place, to which the coast is indebted for its swelling outline. The cities of Rosetta and Damietta which were built upon these mouths, close to the sea, less than a thousand years back, are now six miles distant from it. At the same time that the sediments of the Nile occasions an extension of the land, both the bed of the river and the country which is periodically covered by the overflow of the waters, are from the same cause gradually being raised to a greater elevation. As a proof of this elevation of the soil, it is stated that at Cairo, before the rise of the river is deemed sufficient for the purpose of irrigation, its height must exceed 3½ feet, that which was requisite ten centuries ago. According to this statement, the ground must have been raised at the rate of nearly 4¼ inches in a century. The ancient monuments of the land all have their bases more or less, covered by the mud which has been, for ages, accumulating around them.

The delta of the Rhone undergoes a similar augment-

ation, and it would appear, that the arms of that river have, in the course of 1800 years, become longer by three leagues; and that many places which were once situated on the brinks of the sea, or of large pools, are now several miles distant from the water. In Holland and Italy, the Rhine and the Po, since they have been banked up by dikes, raise their beds and push forwards their mouths into the sea with great rapidity. Many cities which, at periods within the range of history, even flourishing sea ports, have, by the encroachments on the water, been deprived of their importance. It is with extreme difficulty that the Venecians are able to preserve from the main land the Lagunes,—extensive sheets of water, but so shallow that they, in no part, exceed 6 or 7 feet in depth; and in all probability Venice is destined to experience the fate of Ravenna, which, according to Strabo, stood among Lagunes in the time of the Roman Emperor Augustus, but is now a league from the shore.

The river Po in Italy has the level of its bottom so much raised that the surface of its waters is now higher than the roofs of the houses in Ferrara; and the Adye and the Po are higher than the whole tract of country lying between them. The high level above the surrounding plain, attained by the Rhine and the Meuse in Holland, since they have been banked up; the additions of land that have been made along the shores of the north sea, in Holstein, Friesland, Groningen &c.; and the diminution of the Sea of Azoy, by the entrance of alluvial matter from the Don, are further instances of the changes which nature is able to produce by the most simple means.

There are several instances in mountainous and marshy countries of small lakes having been dried up from different causes—such as the crystallization, or deposit of substances which the waters had previously held in solution; the gradual union of floating islands, and the collection of matter arising from the lake being the seat of animal and vegetable life; but it is evident, from their very slow progress, that the effects produced in these ways cannot be upon a very large scale.

We must now mention some changes of a destructive nature. There are the breaking down of steep coasts by the waves, and the throwing up of Sandhills, which the wind afterwards assist in pushing forward and dispersing over the adjacent land. The first is a very common occurrence; the sea detaches fragments from the foot of the cliffs, or else wastes it away, and then the upper parts deprived of support, fall down. The broken parts that collect at the base in consequence of these falling downs, serve, more or less, and for a longer or shorter period, according to their position and hardness of material, to protect the cliff from further ravages. The circumstances also which cause the slipping down or breaking away of masses of rock and earth, among mountains, operate in a similar manner where there are shores of a steep character. Springs filter through and displace the soft strata, and thus the more solid formations are left without support; the consequence is, that at times large spaces of land slide or fall down from above; it is by such means as these that the 'land slips,' on the southern shore of the Isle of Wight have been produced. The same thing happens, but on a grander scale, upon the coast of the Crimea; whole tracts are there carried down, sometimes bearing upon them the houses of the natives, which have, notwithstanding been known to escape without injury.

The action of the sea, when the coast is low, and the bottom sandy, leads to very different results. The waves then push the sand forward upon the shore, where, at every ebb of the tide, it becomes partially dried: and the wind, frequently blowing from the sea, drifts it upon the beach. By little and little, hillocks or downs of sand are created, the higher parts of which are continually carried in land; so that unless the inhabitants of the country succeed in fixing them by causing suitable plants to take root in their soil, they move slowly on and overwhelm fields and dwellings with inevitable ruin. Perhaps the most remarkable instance of the mischief occasioned by the moving downs is to be found on the French Coast of the Bay of Biscay, south of the river Gerondi, where

they have already overwhelmed a great number of villages, mentioned in the records of the middle age, and not long ago, in the single department of the *Landes* were threatening ten with unavoidable destruction. One of these villages, named Mimisan, had been struggling against them for twenty years, with the prospect of a sand-hill of more than sixty feet in height visibly approaching it.

The river Adour is now turned to the distance of more than 2,000 yards out of its former course. The progress of these downs has been estimated at 60 feet yearly, and in some places at 72 feet; at this rate, it is calculated that it will require 2,000 years to enable them to reach Bourdeaux.

## CHAPTER III.

## OF THE AIR OR ATMOSPHERE.

### Section I.

*On Currents in the Atmosphere.*

It does not belong to our present subject to investigate the properties and component parts of the atmosphere, but it will be proper to notice the agitations or movements which are constantly taking place in that fluid. A change in the temperature of a portion of air; an increase or a diminution of the quantity of water which it holds in a state of vapour; in short, any circumstance which causes it either to contract or to expand, destroys the equilibrium subsisting among the different parts of the atmosphere, and occasions a rush of air that is, a *wind*, towards the spot where the balance has been destroyed.

Every one knows that the velocity and force of winds are exceedingly various; accordingly, several methods have been suggested, and instruments invented, in order to determine their amount with some degree of exactness. In the fifty-first volume of the "Philosophical Transactions," there is a table of the different velocities and forces of winds, drawn up from a considerable num-

ber of facts and experiments; the following particulars are extracted from it:—

| Velocity of the Wind. | Perpendicular force, on one square foot, in Avoirdupois pounds. | Common Appellations of the forces of such Winds. |
|---|---|---|
| Miles in an hour. | dec. parts, | |
| 1 | .005 | Hardly perceptible. |
| 4 | .079 | Gentle, pleasant wind. |
| 5 | .123 | |
| 10 | .492 | Brisk gale. |
| 15 | 1.107 | |
| 30 | 4.429 | High wind. |
| 35 | 6.027 | |
| 50 | 12.300 | A storm. |
| 80 | 31.490 | A hurricane. |
| .00 | 49.200 | |

Winds may be divided into three classes—those which flow *constantly* in the same direction, those which are *periodical*, and those which are variable. It must be observed that the terms which express the direction of winds are employed in a sense quite contrary to that in which they are used when we speak of the direction of currents in the ocean; a westerly current, for example, signifies a current flowing *towards* the west, but a westerly wind signifies a wind coming *from* that quarter.

The *permanent* winds are those which blow constantly between, and a few degrees beyond the tropics, and are called *trade-winds*. On the north of the equator, their direction is from the north-east (varying at times a point or two of the compass each way); on the south of the equator, they proceed from the south-east. The origin of them is this:—the powerful heat of the torrid zone rarefies or makes lighter the air of that region; the air, in consequence of this rarefaction, rises, and to supply its place a colder atmosphere from each of the temperate zones moves towards the equator. But (as in the case of the polar currents in the ocean), these north and south winds pass from regions, where the rotatory motion of the earth's surface is less, to those where it is greater. Unable at once to acquire this new velocity, they are left behind, and instead of being north and south winds, as they would if the earth's surface did not turn round, they

become *north-east* and *south-east* winds. The space include between the second and fifth degrees of north latitude, is the *internal boundary* of the two winds; and this space experiences calms, frequently interrupted, however, by violent storms. The reason why it is situated to the north of, instead of exactly at, the equator, seems to be that the northern hemisphere is warmer than the southern; for since the trade-winds are the result of the continual ascent of heated air in the equatorial parts, their internal boundary will be where the principal ascent is going on,—that is, where the annual temperature is the highest; which, on account of the above-mentioned inequality of temperature in the two hemispheres, will not be at the equator, but somewhat to the north of it. The *external limits* of the trade-winds are at a medium in about the 30th degrees of north and south latitude, respectively; but each limit, as the sun approaches the neighbouring tropic declines further from the equator. The position of the sun has an influence also on their strength and direction; for when that luminary is near the tropic of Cancer the south-east wind becomes gradually more southerly, and stronger, and the north-east weaker, and more easterly; the effect is reversed when he gets towards the tropic of Capricorn.

The trade-winds would blow regularly round the whole globe within the distance of about 30 or 40 degrees from the equator each way, if the space within those limits were all covered with water; but the uneven surface and unequal temperature of the land divert and derange them: it is on this account that the trade-winds are constantly experienced only over the open ocean. The larger the expanse of ocean over which they range, the more steadily they blow: thus in the Pacific they are commonly more steady than in the Atlantic ocean, and in the south than in the north Atlantic. In sailing from the Canaries to Cumana, on the north coast of South America, it is hardly ever requisite to touch the sails of the vessel. The voyage across the Pacific, from Acapulco on the west coast of Mexico, to the Phillippine islands, is performed with equal facility; and if there

were a channel through the isthums of Panama, a westward passage from Europe to China would be more speedy and safe than the usual navigation thither round the Cape of Good Hope; the only interruption to the evenness of this voyage would be in the Caribbean Sea and the Gulf of Mexico, where the trade-wind blows impetuously, and is sometimes interrupted by westerly winds. It would not be possible, however, to return by the same route, because in sailing, east way must be made to the northward, in order to get beyond the region of the trade into that of the variable winds. Both in the Atlantic and in the Pacific Ocean, the current of the trade winds becomes broader and more directly east in its course, as it advances from one side to the other of those extensive basins. On the west coast of Africa, owing to the rarefaction which the air undergoes over that continent, the wind is mostly turned towards the shore; from Cape Bojador to Cape Verd it is generally north-west, and thence to the island of St. Thomas, under the equator, it bends gradually first to the west and then to the south-west. Along the coasts of Chili and Peru a south wind prevails. These are two instances of the interruption which the trade winds experience in the neighbourhood of large masses of land.

In the Indian Ocean the south-east trade-wind prevails between 28° and 10° of south latitude, from within a few degrees of the east side of Madagascar, nearly to the coast of New Holland; but from the 10th degree of south latitude to the northern shores of that ocean, the uniformity of the tropical movements of the atmosphere is destroyed by the *monsoons**, which belong to the class of *periodical* winds. These blow half the year from one quarter, and the other half from the opposite direction: when they shift, variable winds and violent storms prevail for a time, which render it dangerous to put to sea. They of course suffer partial changes in particular places, owing to the form and position of the lands, and to other circumstances, but it will be sufficient to give their gene-

* From the Malay word *mussin*, which signifies *a season*.

ral limits and directions. Northward from the third degree of south latitude, a *south-west* wind blows from April to October—from October to April a *north-east*; these monsoons extend over the China sea, but here they incline more to the direction of north and south. Between the 3d and 10th degrees of south latitude, a *north-west* wind blows from October to April, and a *south-east* during the other six months of the year: the former is seldom steady in the open sea, but in December and January it sometimes extends northwards a degree or two beyond the equator. These two monsoons have the greatest strength and regularity in the Java Sea, and thence eastward towards New Guinea. The facts above exhibited may be thus summed up:—from April to October a *south-west* wind prevails north of the equator, southward of this a *south-west* wind—from October to April, a *north-east* wind north of the equator and a *north-west* between the equator and 10° of south latitude; south of this the usual trade-wind, which is in motion through the whole year.

In attempting to account for these movements of the atmosphere over the Indian Ocean, the first thing which strikes us is, that the north-east and south-east monsoons which are found the one on the north and the other on the south sides of the equator, are nothing more than the trade-winds blowing for six months, and then succeeded for the remainder of the year by winds directly opposite. It is also to be noticed that the south-west monsoon in the northern, and the north-west monsoon in the southern hemisphere, each prevails while the sun is perpendicular to their respective regions: they are, therefore, connected with the immediate presence of that luminary. If the Indian Ocean were not bounded as it is by land on the north, the trade-winds would blow over it (at least in the central parts) as they do in the Atlantic and Pacific Oceans. But it is well known that water, owing to its transparency, is very little warmed by the sun's rays, whereas the land is powerfully heated by them; consequently, when the sun is between the equator and the tropic of Cancer, India, Siam, and the adjacent

countries, become much hotter than the ocean; the air over them gets rarefied and ascends; colder air then rushes in from the Indian Ocean, and a *south-west* wind is produced. When the sun, however, has crossed to the south of the equator, these countries become gradually cool, and the north-east trade-wind resumes its course. At the same time the *north-west* monsoon commences in the southern hemisphere, in consequenee of the air over New Holland being rarefied by the presence of the sun.

The monsoons in the Red Sea blow in the direction of the shores; and a similar effect is observed in the Mozambique channel, between Africa and Madagascar, where these winds follow the line of the channel. On the coast of Brazil, between Cape St. Augustine and the island of St. Catherine, and in the bay of Panama, on the west of the isthmus of that name, periodical winds occur somewhat similar to the monsoons of Asia.

The *land* and *sea-breezes*, which are common on coasts and islands situated between the tropics, are another kind of periodical winds. During the day, the air, over the land, is strongly heated by the sun, and a cool breeze sets in from the sea; but in the night the atmosphere over the land gets cooled, while the sea, and consequently the air over it, retains a temperature nearly even at all times; accordingly, after sun-set, a land breeze blows off the shore. The sea-breeze generally sets in about ten in the forenoon, and lasts till six in the evening; at seven the land-breeze begins, and continues till eight in the morning, when it dies away. These alternate breezes are, perhaps, felt more powerfully on the coast of Malabar than anywhere—their effect there extends to a distance of twenty leagues from the land. During summer, the *sea-breeze* is very perceptible on the coasts of the Mediterranean, and sometimes even as far north as Norway.

We thus perceive that within the limits of from 28 to 30 degrees on each sides of the equator, the movements of the atmosphere are carried on with great regularity; but beyond these limits, the winds are extremely variable and uncertain, and the observations made have not yet

led to any satisfactory theory by which to explain them. It appears, however that beyond the region of the trade-winds, the most frequent movements of the atmosphere are from the *south-west*, in the north temperate zone, and from the *north-west*, in the south temperate zone. This remark must be limited to winds blowing over the ocean and in maritime countries; because those in the interior of continents are influenced by a variety of circumstances, among which, the height and position of chains of mountains are not the least important. These south-west and north-west winds of the temperate zones are most likely occasioned in the following manner:—In the torrid zone there is a continual ascent of air, which, after rising, must spread itself to the north and south in an opposite direction to the trade-winds below: these upper currents, becoming cooled above, at last descend and mix themselves with the lower air; part of them may perhaps fall again into the trade-winds, and the remainder, pursuing its course towards the poles, occasion the north-west and south-west winds of which we have been speaking. It has also been conjectured that these winds may frequently be caused by a decomposition of the atmosphere towards the poles, from part of the air being at times converted into water.

*Hurricanes* have been supposed to be of electric origin. A large vacuum is suddenly created in the atmosphere, into which vacuum the surrounding air rushes with immense rapidity, sometimes from opposite points of the compass, spreading the most frightful devastation along its tract, rooting up trees, and levelling houses with the ground. They are seldom experienced beyond the tropics, or nearer the equator than the 9th or 10th parallels of latitude; and they rage with the greatest fury, near the tropics, in the vicinity of land or islands, while far out in the open ocean they rarely occur. They are most common among the West India islands, near the east coast of Madagascar, the islands of Mauritius and Bourbon, in the Bay of Bengal at the changing of the monsoons, and on the coasts of China.

*Whirlwinds* sometimes arise from winds blowing among

lofty and precipitous mountains, the form of which influences their direction, and occasions gusts to descend with a spiral or whirling motion. They are frequently, however, caused by two winds meeting each other at an angle, and then turning upon a centre. When two winds thus encounter one another, any cloud which happens to be between them is of course condensed and turned rapidly round; and all substances sufficiently light are carried up into the air by the whirling motion which ensues. The action of a whirlwind at sea occasions the curious phenomenon called a *water-spout*, which is thus described by those who have witnessed it. From a dense cloud a cone descends in the form of a trumpet with the small end downwards; at the same time, the surface of the sea under it is agitated and whirled round, the waters are separated into vapour, and ascend with a spiral motion till they unite with the cone proceeding from the cloud; frequently, however, they disperse before the junction is effected. Both columns diminish towards their point of contact, where they are not above three or four feet in diameter. In the middle of the cone forming the water-spout, there is a white transparent tube, which becomes less distinct on approaching it, and it is then discovered to be a vacant space in which none of the small particles of water ascend: and in this, as well as around the outer edges of the water-spout, large drops of rain precipitate themselves. In calm weather, water-spouts generally preserve the perpendicular in their motion; but when acted on by winds they move on obliquely—sometimes they disperse suddenly, at others they pass rapidly along the surface of the sea, and continue a quarter of an hour or more before they disappear. A notion has been entertained that they are very dangerous to shipping, owing to the descent, at the instant of their breaking, of a large body of water sufficient to sink a ship; but this does not appear to be the case, for the water descends only in the form of heavy rain. It is true, that small vessels incur a risk of being overset if they carry much sail; because sudden gusts of wind, from all points of the compass, are very common in the vicinity of water-spouts.

## Section II.

## ON PHYSICAL CLIMATE.

Circumstances which determine its character—Mean annual Temperature—Extremes of Heat and Cold—Isothermal Lines—Temperature of the Southern and Northern Hemispheres compared—Quantity of Evaporation and of Rain in various Latitudes—Character of the Seasons in the different Zones.

The term *climate* is applied to the state of the air, in order to express that particular combination of temperature and moisture which exists in the atmosphere of any greater or less extent of country. The climates of different regions of the globe, and the causes which occasion their great diversity, are interesting matters of inquiry. If an uniform climate had been communicated to the whole globe, we should not have seen such wonderful variety among the animal and vegetable tribes; and many things that now raise the delight, or administer to the necessities of the human race would have been entirely unknown. It might at first be imagined that the climate of any particular place depended solely upon the action of the sun; but, upon further consideration, we shall find that there are other circumstances to be taken into account: were it not so, any two places having the same latitude, and consequently receiving the sun's rays at the same angle, would enjoy similar climates, which is by no means the case. It is a wise ordination of Providence that the sun's action is modified in such various ways, as to produce a more equal distribution of heat over the surface of the globe than would otherwise have existed; by means of which, large regions are adapted to the residence and support of man, that would else, from extreme heat or cold, have been uninhabitable.

There are eight circumstances which determine physical climate:—1. The power of the sun's immediate action, which increases in proportion as we approach the equator; 2. elevation of the ground above the level of the ocean; 3. position with respect to the great seas; 4. quarter towards which the surface of the country slopes; 5. position and direction of chains of mountains;

6. nature of the soil; 7. degree of cultivation and improvement to which the country has arrived; 8. prevalent winds. 9] [illegible]

1. The amount of the immediate solar heat depends upon the position of the sun in the ecliptic, because to all places (whatever their distance from the equator) this position determines the length of the day, and the direction in which the sun's rays strike the earth. When the sun remains a long time above the horizon, his continued action causes a powerful accumulation of heat; the nights also being short, but little of this heat escapes during his absence. On this account it is, that even within the arctic circle the summer temperature is sometimes quite oppressive*. The direction in which the rays fall upon the earth is another important consideration; their greatest force being experienced when they are perpendicular to the surface. On the contrary, when the sun is near the horizon, his rays merely glance along the ground, and many of them, before they reach it, are absorbed and dispersed, owing to the density of the lowest stratum of the atmosphere along which they have to pass. Bouguer calculated that, out of 10,000 rays falling upon the earth's atmosphere, 8128 arrive at a given point if they come perpendicularly; 7024, if the angle of direction is 50 degrees; 2831, if it is 7 degrees, and only 5, if the direction is horizontal.

2. It is well known how the temperature of a place is influenced by the elevation of the land. In proceeding from the equator towards either of the poles, without altering our height above the level of the sea, we must travel a great distance before we find the mean annual temperature reduced even a few degrees; but, by increasing our elevation, a rapid change of temperature will be experienced, till we arrive at the point where constant frost prevails. The extreme cold which exists in the upper region of the atmosphere seems to be owing to the expansion of the air (see chap. vii. of the

* In Norway, as high as latitude 70 degrees, the thermometer has been seen to rise above 80 degrees.

*Treatise on Heat*); partly, also, to the circumstance of that region being beyond the reach of the heat reflected from the surface of the earth. The decreases of heat at equal ascents, are not altogether uniform, as they take place more rapidly in the higher parts of the atmosphere. The annexed table, abridged from one drawn up by Professor Leslie, shows that even under the equator, where the sun's direct influence is most powerful, an ascent of rather more than 15,500 feet (about 2⅞ miles) above the level of the sea, will bring us within the region of perpetual frost. This provision of nature of course increases considerably the number of habitable countries within the torrid zone.

| Latitude. | Mean Temperature at the level of the sea. | Height of Curve and Congelation. |
|---|---|---|
| 0 | 84.2 Fahr. | 15,207 feet. |
| 10 | 82.6 | 14,764 |
| 20 | 78.1 | 13,478 |
| 30 | 71.1 | 11,484 |
| 40 | 62.6 | 9,001 |
| 50 | 53.6 | 6,334 |
| 60 | 45 | 3,818 |
| 70 | 38.1 | 1,778 |
| 80 | 33.6 | 457 |
| 90 | 32 | 0 |

3. The effect of the sea is to *equalize* temperature, so that a maritime country is not liable to such extremes, either of heat or cold, as an inland one. The sea itself being of a very equable temperature, the winds which pass over an extent of it partake somewhat of the same character. When a *cold* wind passes over sea it receives part of the warmth of the water, the upper particles of which being thus rendered cooler, and consequently heavier than those below, descend and are succeeded by warmer particles; so that there is a *continual* tendency in the sea to temper a cold wind passing over its surface. A cold wind, blowing overland, is at first rendered warmer by the earth's surface; but this surface quickly becoming cooled, ceases to have any effect upon the wind, which, therefore, travels on with undiminished rigour. Again, a warm wind, in passing over sea, is cooled by the agitation which it produces, bringing up cooler water from

below, as well as by the constant evaporation which it occasions; the surface of the water also cannot, as that of land, be powerfully heated by the sun's rays, because it affords them a free passage, and therefore it cannot communicate heat to the atmosphere in the degree which the land does. From these circumstances it results, that, though a place situated inland, and another upon a coast may have the same mean annual temperature, the range of the thermometer at each will be very different, the summers of the latter will be cooler, and the winters milder than those of the former. It is from this cause that islands are so much more temperate than continents. It follows, too, that countries in our hemisphere will be rendered warmer by having large tracts of land to the south, and sea to the north, and cooler when the relative position of these two is reversed. This fact is exemplified by a comparison of the climate of India with that of Africa, north of the equator, the heats of the former country being much more supportable than those of the latter. Not only the temperature of a wind, but also its degree of moisture, depends upon the nature of the surface over which it passes. A wind coming up from the ocean is loaded with vapours, but one sweeping over an extent of land is rendered dry and parching. This explains to us why, in our own island, a south-west and an easterly wind are so opposite in character.

4. The aspect of a country has an influence upon its climate, for this reason, that the angle at which the sun's rays strike the ground, and consequently the power of those rays in heating it, varies with the exposure of the soil relatively to that luminary. When the sun is elevated on the meridian 45 degrees above the horrizon, his rays fall *perpendicularly* on the side of a hill facing the south at an equal angle, while the plain below receives them at an *angle of 45 degrees.* Supposing the north side of the hill to have a similar slope, the rays would run *parallel* to its surface; and their effect be very trifling, but if the declivity were still greater, the whole surface would be in the shade. This, though an extreme case, serves to show why temperature varies with the

inclination of the earth's surface. Since the warmest part of the day is not when the sun is on the meridian, but, owing to the accumulation of the heat, two or three hours afterwards, it follows that, in our hemisphere, a south-south-west or south-western aspect is the warmest, and north-north-east or north-eastern the coldest, if no local circumstances exist to make it otherwise. The effect of aspect is, of course, most strikingly seen in regions covered with high mountains. In the Vallais in Switzerland, the Alps are on one side covered with ice, while vineyards and orchards flourish on the other.

5. Mountains affect a climate in more ways than one. They attract the vapours in the atmosphere, and causing them to condense, give rise to those violent rains which are often experienced in the neighbourhood of lofty ranges. They also afford shelter from winds. In narrow valleys, the sides of which in summer strongly reflect the sun's rays, this shelter sometimes renders the heat very injurious. One reason why the central and southern parts of European Russia are exposed to greater cold than their latitude and inclination southward would lead us to expect, is the absence of any chain of mountains to protect them from the full influence of the winds blowing from the White Sea and the Ural Mountains. The inhospitable climate of Siberia arises from its descent towards the north exposing it to the winds of the Frozen Ocean, while at the same time the vast mountainous chains that cross central Asia, intercept the southern winds whose access would tend to mitigate the rigour of the atmosphere.

6. It is evident that the nature of the soil must very materially operate upon climate. One soil acquires heat, keeps its acquired heat much longer, or reflects it more readily, than another. One, which from its porous character allows the rain descending upon it to pass freely into the earth, will emit much fewer exhalations than one which retains the waters near the surface. Thus clayey or marshy grounds lower the temperature, and especially in hot and humid climates, affect the atmosphere in a manner pernicious to health; on the other

hand, those which are light, stony, or calcareous, tend to make the atmosphere salubrious. The great cold, and the *unwholesome* air that prevail in the Russian governments of Astracan and Orenburg, lying to the north of the Caspian Sea, are attributed partly to the saline nature of the soil; and it is well known that the arid tracts of sand in Africa and Arabia, conduce not a little to the access of heat under which those countries labour.

7. Without cultivation few climates would be healthy or agreeable. In countries to which the labours of civilized man have never been extended, the rivers, spreading themselves over the low grounds, form pestilential marshes, and forests, thickets and woods are so numerous and impenetrable, as to prevent the earth from receiving the beneficial influence of the sun's rays. The air, from these causes, is constantly filled with noxious exhalations. But the efforts of the human race, conducted with skill and perseverance, produce a surprising change: marshes are drained; rivers embanked; the soil broken up by the plough is exposed to the sun and winds, and the clearing away of the forests raises the temperatue, and allows a freer circulation to the atmosphere. There is little doubt that many parts of Europe enjoy a midler climate now than they did in the time of the Romans, or even at periods much more recent. Several districts in North America have experienced, as the country has become more widely settled, a similar improvement of climate. The destruction of forests may, however, be carried to a pernicions extent, either by depriving a country of shelter from particular winds, or (especially in hot climate) by lessening too much the quantity of moisture; it being well known that there is a great evaporation from the leaves of vegetables. The sultry atmosphere and dreadful droughts of the Cape de Verde islands are owing to the destruction of the forests; and Greece, Italy, and other countries are said to have been deteriorated in climate from the same cause. It is attributed to this also that the southern part of Iceland is more accessible than formerly to the cold which proceeds from the Arctic Ocean.

8. The combined influence of the several causes of physical climate which we have been considering will be variously modified by the *prevalent winds* of a country. This is obvious enough, because we know that the character of a wind depends upon the quarter whence it comes, and the surface over which it passes. Great Britain, for example, would in a great measure lose its insular climate, if its prevailing winds came across the continent, instead of from the Atlantic Ocean.

Notwithstanding the several circumstances which we have thus pointed out as influencing climate, and which occasion numerous local irregularities, the temperature, with these exceptions, become gradually lower as we pass from the equator towards either of the poles. By this is not to be understood the temperature of any particular day, or even season, but the *mean annual temperature*, which is obtained by adding together the temperatures of all the months,* and dividing the sum by the number of months in the year; so that the mean annual temperature expresses that height at which the thermometer would stand at any place, if we could suppose it

* The temperature of each month is the average of all the daily temperatures in the month, and the daily temperature is the average of several observations made at stated periods, every hour or half hour, for instance, each day (24 hours). It is evident that such frequent observations would be very troublesome and shorter methods of discovering the mean annual temperature of a place have therefore been sought after. Rules have been laid down for calculating what this under different parallels of latitude, and the results no doubt approach very near to the truth; but it would obviously be incorrect to apply these rules to any particular place, because we should be uncertain how the climate of that place was affected by local circumstances. The best method is to ascertain at what period in each day (taking one day with another) the thermometer stands at its mean height for the day; and when this has been ascertained, one observation each day, at that period, will be sufficient. In this country it would appear that the time at which the thermometer shows the mean heat for the day, is about a quarter or half past eight in the morning. Another method of discovering the mean annual temperature at any place, is to observe the height of the thermometer in cavities at some depth below the earth's surface, it being found that this height nearly corresponds with the mean annual height in the air above. M. Lacroix, in his work on Physical Geography, states that in the caves below the Observatory at Paris, (at. 49°) about 85 feet below the surface. Fahrenheit's thermometer constantly stands between 52° and 54° scarcely ever varying two degrees, while above, the difference of temperature between summer and winter sometimes exceeds 90°. In the salt mines at Wielickza, in Poland (lat. 50°) from the depth of 320 to that of 745 feet, the thermometer stands at about 59. At Cairo, in Egypt, (lat. 30°), at the bottom of Joseph's well (210 feet deep), it stands at 70°; in the mines of Mexico (lat. 20°), 1650 feet below the surface, it stands at 74½°. In these heights we discern how the temperature increases on approaching the equator.

perfectly stationary throughout the whole year. It is not sufficient, however, to take one year only, but a series of at least ten or fifteen years, from the *mean* result of which series a conclusion nearly accurate may be drawn. Though the temperature of a place is continually varying, and though the changes occur frequently in the most sudden manner, it never differs more than a certain number of degrees either way from its mean state; and when it has reached either extreme, a reaction may shortly be expected. In the torrid zone any excessive accumulation of heat is prevented by the constant blowing of the trade-winds from cooler regions: and in the frigid zones the tendency to great extremes which arises from the continued presence of the sun in summer, and his long absence in winter, is counteracted by the circulation of the atmosphere, and by the circumstance that the fields of ice, in melting, absorb large quantities of heat, while on the other hand warmth is given out when the surface of the ocean is being frozen over.—(See chap. ix. of the *Treatise on Heat.*)

The extremes of temperature which have been witnessed in different parts of the globe are, nevertheless, very considerable. In New South Wales, Fahrenheit's thermometer sometimes rises to 100 degrees and upwards; at Pekin, in China, it has been seen at 110°, and at different places in India at 110°, and even 115°. Major Denham, in his late travels in Africa, observed it more than once at 113°; and at Belbeis, in Egypt, it is said to have risen, under the influence of the hot wind from the desert, to 125°.* These heights are intended to express the degree of heat in the *shade*. The accuracy of the observations depends upon the circumstances under which they were made, since it is requisite that the thermometer should be in a situation freely exposed to the outer air, also where there are no surfaces imme

* When the thermometer is raised to such an extraordinary height as this, it is probably the effect produced by very fine particles of sand which are carried along by the atmosphere. Humboldt, in the arid plains of South America, has, during a *wind of sand*, seen it at 114½ degrees nearly: while in Fezzan, in the North of Africa, it has risen, doubtless from the cause just noticed, to 125,6 degrees.

diately near to reflect the sun's rays. The most extreme cold experienced is the northern parts of Asia and America. In Siberia, as far south as the 58th degree of latitude, M. Pallas observed the freezing of mercury*. The same phenomenon is by no means unusual at Quebec. At Hudson's Bay the spirit thermometer has sunk to—50°, and at Melville island, (N. lat. 74¼°,) where Captain Parry wintered in his first north-western expedition, it fell, on the 15th February, 1820, to 55 degrees below *zero.*

A treatise upon *isothermal*† *lines*, published some years ago by M. Humboldt, gives several curious results drawn from various observations upon temperature made by himself and others. A few of these it will be proper to notice here, because they illustrate, in a striking manner, the fact upon which we have already remarked, that the climates of places do not depend solely upon the direct action of the sun. If it were so, all places having the same latitude would experience the same mean annual temperature. It had long been known that this was not the case, especially on comparing Europe with America; but M. Humboldt's statements will enable us to form some idea of the amount of the difference. According to that philosopher, the isothermal line which indicates the temperature of 32 degrees (the freezing point of water) passes between Ulea, in Lapland (lat. 66°) and Table Bay, on the coast of Labrador, in North America, lat. 54°. The isothermal line of 41 degrees passes near Stockholm, lat. 59½°, and St. George's Bay, Newfoundland, lat. 48°. The line of 50 degrees runs through the Netherlands, lat. 51°, and near Boston, in the United States, lat. 42½°; that of 59 between Rome and Florence, lat. 43°; and near Raleigh, in North Carolina lat. 36°. Taking similar latitudes, the following are the differences of temperature between the west of Europe and the east of North America:—

* This takes place when the mercury has sunk to 39 or 40 degrees below *zero*.

† This is derived from two Greek words, and signifies *equal heat* or *temperature*. An isothermal line, therefore, is a line drawn over places which have the *same temperature* (*annual*, unless otherwise expressed.)

| Latitude. | Mean temperature in the West of Europe. | Mean temperature. in the East of America. | Difference. |
|---|---|---|---|
| ° | ° | ° | ° |
| 30 | 70.1 | 66.8 | 3.3 |
| 40 | 63.1 | 54.5 | 8.6 |
| 50 | 50.8 | 37.9 | 12.9 |
| 60 | 40 | 24 | 16 |

From the annexed table, there appears to be nearly as much difference between the mean temperatures of the eastern and western parts of the old continent as between those of the opposite shores of Europe and America:—

| Places. | Latitude. | | | Longitude. | | | Mean temperature. |
|---|---|---|---|---|---|---|---|
| St. Maloes...... | 48° | 39 | N. | 1° | 57 | W. | 54.5° |
| Amsterdam...... | 52 | 22 | | 4 | 40 | E. | 53 4 |
| Copenhagen ...... | 55 | 41 | | 12 | 30 | | 45.7 |
| Upsala........... | 59 | 51 | | 17 | 48 | | 41.9 |
| Naples.... ..... | 40 | 50 | | 14 | 10 | | 63.5 |
| Vienna.......... | 48 | 11 | | 16 | 22 | | 50 5 |
| Warsaw......... | 52 | 14 | | 21 | 10 | | 48.6 |
| Moscow......... | 55 | 45 | | 37 | 31 | | 40.1 |
| St Petersburgh... | 59 | 56 | | 30 | 25 | | 38.8 |
| Pekin (China).... | 39 | 54 | | 116 | 28 | | 54.9 |

M. Humboldt, after tracing the isothermal lines across America, concludes that, in California and thence northward along the western side of that continent, the temperature is nearly the same as in similar latitudes on the western side of Europe. "Europe," he then observes, "may be considered altogether as the western part of a great continent, and, therefore, as being subject to all the influence which causes the western sides of all continents to be warmer than the eastern. The same difference which has been observed between the two shores of the Atlantic, exists between the two opposite coasts of the Pacific. In the north of China, the extremes of the seasons are much more felt than in the same latitudes in New California, and at the mouth of the Columba. On the eastern side of North America, the same extremes occur as in China. New York has the summer of Rome and the winter of Copenhagen. Quebec has the summer of Paris and the winter of Petersburgh. In the same manner, at Pekin, which has the mean tem-

perature of Britain, the heat of summer is greater than at Cairo, and the cold of winter as severe as Upsal. This analogy between the eastern coasts of Asia and America sufficiently proves that the inequality of the seasons depends upon the prolongation and enlargement of the continents towards the pole, and upon the frequency of the north-west winds and not upon the proximity of an elevated tract of country." The following table illustrates the preceding remarks:—

| Places. | Latitude, North. | Mean annual temperature. | Mean temperature. Winter. | Spring. | Summer. | Autumn. | Coldest M | Hottest M | Difference in the heat of these mts. |
|---|---|---|---|---|---|---|---|---|---|
| Philadelphia. | 39.56 | 54.86 | 33.98 | 53.06 | 75.20 | 56.32 | 32.70 | 77.00 | 44.30 |
| Pekin....... | 39.54 | 54.86 | 26.42 | 56.30 | 82.58 | 54.32 | 24.62 | 84.38 | 59.76 |
| Nantes....... | 47.13 | 54.68 | 40.28 | 54.50 | 68.72 | 55.58 | 39.02 | 70.52 | 31.50 |
| Rome........ | 41.53 | 60.44 | 45.86 | 57.74 | 75.20 | 62.78 | 42.08 | 77.00 | 34.92 |
| Paris........ | 48.50 | 51.44 | 37.92 | 49.64 | 64.40 | 51.26 | 35.96 | 67.46 | 31.50 |
| Quebec....... | 46.47 | 41.72 | 14.18 | 38.84 | 68.00 | 46.04 | 12.74 | 73.40 | 60.66 |
| Upsala....... | 59.51 | 41.9 | 24.98 | 39.38 | 60.20 | 42.80 | 24.26 | 61.88 | 37.62 |

The fact that places which have the same annual temperature experience very different seasons, is clearly exhibited in this comparison. From Humboldt's inquiries, it appears that the lines which mark the winter temperature deviate much more from the parallels of latitude than those which express the mean annual temperature. In Europe the latitudes of two places which have the same annual heat, never differ more than 8° or 9°: but the difference of latitude in those having the same winter temperature is sometimes no less than 18° or 19°. The winter of Scotland is as mild as that of Milan. With respect to summer, the same heat takes place at Moscow and at the mouth of the Loire, though the former is nearly 9 degrees north of the latter. Ireland is remarkable for mild winters and cold summers; the mean temperature in Hungary for the month of August is 71°.6, while in Dublin it is no more than 60°.8.

It is generally believed that, beyond a certain distance from the equator, the temperature of the southern is lower than that of the northern hemisphere. In speaking of the temperature of the ocean, we have already observed that ice is fallen in with much sooner in sailing towards the south, than it is in approaching the north pole. Humboldt says, that near the equator, and indeed through the whole of the torrid zone, the temperature of the two hemispheres appears to be the same; but that the difference begins to be felt in the Atlantic about 22° of latitude; the mean temperatures of Rio Janeiro and Havannah, places at about an equal distance from the equator (23 degrees) being in the latter instance 76°.4, and in the former only 74°.5.—The southern climates generally differ from the northern with respect to the distribution of temperature through the different parts of the year. In the southern hemisphere, under the isothermal lines of 45° and 50°, there are summers which, in our hemisphere, belong to the lines 35½° and 41°. There is no accurate information as to the mean temperature of any place beyond 50° of south latitude; but there is every reason to suppose that it differs considerably from that of places in the same degree of north latitude.

The same writer, in the second volume of his Personal Narrative, presents the following comparison of the temperature of the air in both hemispheres. The observations employed in drawing it up were all made at sea except those from which the mean temperature for S. lat. 34° was deduced, which were made at the Cape of Good Hope.

| Latitude. | Corresponding Months. | | Mean temperature of the months. Southern Hemisphere. | Northern do. |
|---|---|---|---|---|
| 0°— 15° | December<br>June | Summer | 82.4° | 83.3 |
| 18 | October<br>April | Autumn | 81.5 | 79.7 |
| 2 — 26 | January<br>July | Winter | 72.5 | 66.74 |
| ,, | September<br>March | Autumn | 69.44 | 68.9 |
| 34 | December<br>June | Winter | 56.84 | 59.72 |
| ,, | February<br>August | Winter | 62.24 | 62.6 |
| 43 | July<br>January | Summer | 59.36 | 64.76 |
| 48 | June<br>December | Summer. | 44 6 | 63.86 |
| 58 | July<br>January | Summer | 43.16 | 56.3 |

The coldness of the southern hemisphere has frequently been attributed to a circumstance quite inadequate to explain it, namely, that of the sun being a shorter time (by 7¾ days), on the south, than on the north side of the equator. A much greater influence than we can assign to this cause, must be ascribed to the very large proportion which the ocean bears to the land of the southern hemisphere, in consequence of which its climate differs from that of the northern, in the same way as an insular climate differs from a continental one. But even this is not altogether a sufficient explanation, and there still remains a circumstance that deserves attention. The absence from the south polar regions of any great extent of land, and the manner in which the South American

continent terminates, permit the grand current of the antarctic ocean to flow freely all round that part of the globe, towards the equator. This current, being unchecked till it is lost in the westerly movement of the ocean, carries along with it the circumpolar ice into very low latitudes; and the continual absorption of heat by the melting of the ice, as it gradually advances into warmer parts, keeps the air at a lower temperature than in the northern hemisphere, where circumstances are not favourable to the passage of the polar ice out of the regions in which it is formed. Beyond the limit, however, at which the ice disappears, but little effect will be produced on the temperature by its melting, and we accordingly find that within the torrid zone, the warmth of one hemisphere is the same as that of the other, and that as far as the 35th, or even 40th degrees of latitude, there is no important difference.

The question has sometimes been agitated, whether the general temperature of the globe suffers any change. Some have gone so far as to imagine that it gradually diminishes, others have been of opinion that it receives an augmentation. Neither of these theories has very solid foundation; it is scarcely more than a century since the thermometer was rendered a correct measure of heat, and the number of observations made with it in different parts of the world is by no means sufficient to form a basis for such sweeping conclusions. If we possessed a regular series of observations taken in various countries, and extending through three or four centuries, we should most likely be enabled to discover a mean state both of temperature and moisture to which the atmosphere continually returns; and there is no doubt that if we could obtain a clear insight into the complex machinery which regulates the seasons, we should behold the same beautiful harmony, and the same system of compensation for temporary and apparent irregularities, which we are able to discern in the movements of the heavenly bodies. Independent, however, of any question as to the general temperature of the globe, a notion has been entertained that throughout Europe, a more mild and genial climate

formerly prevailed: but such historical evidence as can be collected tends to prove exactly the reverse; and that the climate, as might be supposed, has, generally speaking, improved with the advance of cultivation. A discussion of this subject will be found in the first article of the *Edinburgh Review*, No. LIX., published in June, 1818. That article contains a list of the remarkable seasons which have taken place in Europe for several centuries past, and from the view there given we may venture to conclude, that severe cold is of much rarer occurrence than it was in former ages.

Having thus noticed the subject of temperature, it will be proper to advert to the amount of moisture which the atmosphere contains in different parts of the globe. In the course of this inquiry we shall not make use of the results given by the hygrometer*, because that instrument is neither so well known, nor brought to such a correct standard as the thermometer, but merely give the quantity of evaporation, and the depth of rain that has been observed to fall at several places upon the earth's surface.

Other things being equal, evaportion is the more abundant, the greater the warmth of the air *above* that of the evaporating body, and least of all when their temperature is the same. Neither does much take place whenever the atmosphere is more than fifteen degrees colder than the surface upon which it acts. Winds powerfully promote evaporation, because they bring the air into continual, as well as into closer and more violent contact with the surface acted upon, and also, in the case of liquids, increase, by the agitation which they occasion, the number of points of contact between the atmosphere and the liquid. It must be familiar to every person that the same quantity of water spread over a larger space, is dried up in a less period.

In the temperate zone, with a mean temperature of $52\frac{1}{4}$ degrees, the annual evaporation has been found to be between 36 and 37 inches. At Cumana, on the coast of

* Derived from the Greek, and signifies *measure of moisture*.

South America (N. lat. 10½), with a mean temperature of 81.86 degrees, it was ascertained to be more than 100 inches in the course of the year; at Guadaloupe, in the West Indies, it has been observed to amount to 97 inches. The degree of evaporation very much depends upon the difference (greater or less) between the quantity of vapour which the surrounding air is able to contain *when saturated*, and the quantity which it actually contains. M. Humboldt, from observations made in the passage across the Atlantic, found that in the torrid zone, the quantity of vapour contained in the air, is much nearer to the point of saturation than in the temperate zone. The evaporation within the tropics is, on this account, less than might have been supposed from the increase of the temperature.

The quantity of rain falling upon the earth at any place is determined by observing the height of the water collected in a pluviometer or rain-gauge. When an inch is said to have fallen, it implies that the rain which has descended on any given surface would have acquired that depth, supposing none of it to have been absorbed by the ground, and that it received no addition by means of water flowing from the parts adjacent to that surface. The average yearly quantity of rain is greatest within the tropics; and it seems, in general, to diminish the farther we recede from the equator. In the torrid zone it amounts, at a medium, to 100 or 110 inches, while in the north temperate zone it cannot be stated at more than 30 or 35 inches. These quantities are very differently distributed throughout the year in the two zones: the number of rainy days towards the equator is, in the majority of places, *less* than in the higher latitudes, and the rain consequently descends there in the most violent torrents at Bombay, 16 inches have been collected in a gauge in the space of twenty-four hours. In general, much more rain falls in mountainous countries than in plains, and in countries covered with extensive forests than in those where wood is less abundant. Annexed is a table of the annual quantities which have been observed at several places.

| Places. | Latitude. | Mean annual quantity of rain. |
|---|---|---|
| Islands of St. Domingo.. | 19° N. | 120 in. |
| Ditto Grenada......... | 12 | 112 |
| Calcutta .. ........... | 22½ | 70 to 75 |
| Rome.............. .... | 42 | 36 |
| Paris................. | 49 | 21 |
| London............... | 51½ | 23 or 24 |
| Liverpool............. | 53½ | 34 |
| Kendal, Westmoreland.. | 54½ | 60 |
| St. Petersburgh........ | 60 | 16 |
| Upsal ................ | 60 | 16 |

The average annual fall of rain at Bombay in the ten years 1817 to 1826, was 78.1 inches; of those years the most rainy was in 1822, in the course of which nearly 113 inches fell: whereas in 1824, a season of extreme drought and famine, the supply did not much exceed 34 inches. At Arracan, in 1825, nearly 60 inches were registered in the month of July, and above 43 in August; from which we may conclude, that the whole quantity within the year was at least 150 inches. It would seem, however, that at some places within the tropics the fall is much more copious even than this. Humboldt, on the authority of others, mentions two instances of such excessive rain as almost to induce a suspicion of the correctness of the observations. He informs us that a M. Pereira Lago, by means of a pluviometer, found the quantity of rain, in the year 1821, at San Luis do Maranho, in Brazil (S. lat. 2½), to be 280¾ inches; and also, that Captain Roussin relates the fact of more than 160 inches having fallen at Cayenne in the single month of February.—(*See vol.* vi. *of the Translation of Humboldt's Personal Narrative, Note to p.* 276.) —At the same time, these accounts appear less surprising when we reflect, that over some of the immense forests of Guyana there is wet weather almost the whole year, and that incessant rains of four or five months are no uncommon occurrence.

It must not, however, be imagined that the climate of all hot countries is characterised by such abundant rains; for there are many which, from one year to another, are either almost or entirely destitute of rain. This is the

case along an extent of several hundred miles of the coast of Peru, in Egypt and many other parts of Africa, and also in the desert tracts of Arabia. At Cumana, on the North coast of South America, the annual quantity of rain is scarcely 8 inches; and there are other places on the shores of that continent where none falls for several years, but where, nevertheless, vegetation is exceedingly strong, owning to humidity of the atmosphere.

It is well known that the air becomes drier and less loaded with vapours, the higher we ascend. On looking from the top of the Andes towards the Pacific Ocean, a haziness is often seen, spread uniformly over the surface of the waters to the height of 9,500 or 11,500 feet; and this, too, in seasons when the atmosphere, beheld from the coast and at sea, *appears* quite pure and transparent. This decrease of vapour in the upper regions of the atmosphere, combined with the rarefaction of the air, is the cause of the beautiful deep tint which the sky assumes when viewed from the summit of lofty mountains. Small white fleecy clouds are sometimes, however, seen floating above the Andes at the height of 25,000 feet; from which we may judge, that even on the tops of that range the colour of the sky is not so pure as it would appear, if it were possible for an observer to attain a further elevation. In passing also from the temperate to the torrid zone, the azure hue of the sky is found to augment progressively: the transparency of climate which is so much admired in Italy and Greece is far surpassed by that which invests the plains of Quito and Peru, or the fertile island of the Pacific Ocean.

In the torrid zone, the temperature ranges within comparatively small limits; and the various phenomena of the atmosphere occur, from one year to another, with a regular and uniform succession unknown in this part of the world. Two seasons, the *dry* and the *rainy*, divide the year. The latter depends upon the presence of the sun; countries north of the line have their wet season when that luminary is the northern half of the ecliptic, that is, from April to October; while with

southern countries it is exactly the reverse. We cannot fail to be struck with this admirable arrangement for affording shelter from the perpendicular rays of the sun, the unrestrained influence of which would be quite insupportable. Humboldt has given us an account of the atmospheric appearances which succeed each other in that part of South America lying between 4° and 10° of north latitude, and to the east of that branch of the Andes which terminates on the Atlantic side of the lake of Maracaybo. Nothing can surpass the clearness of the atmosphere from the month of December to that of January. The sky is then constantly without clouds; and if one should appear, it is sufficient to excite the whole attention of the inhabitants. The breeze from the east and east-north-east blows with violence. The immense plains (called *Llanos*), which in the rainy season display a beautiful verdure, gradually assume the aspect of a desert; the grass is reduced to powder, the earth cracks; and the alligator and the large serpents remain buried in the dried mud till the first showers of the year awaken them from their lethargy. About the end of February, and the beginning of March, the blue of the sky becomes less intense, the hygrometer indicates greater humidity, and the stars, veiled at times by a slight vapour, lose the steady and planetary light which before distinguished them. The breeze at this period becomes less strong and regular, and is often interrupted by dead calms. The clouds accumulate toward the south-south-east, appearing like distant mountains, with strongly-marked outlines; and from time to time they detach themselves from the horrizon, and traverse the vault of the sky with a rapidity that little corresponds with the feebleness of the wind below. At the end of March, the southern region of the atmosphere illuminated by gleams of lightning; and the breeze then passes frequently, and for several hours together, to the west and south-west. This is a certain sign of the approach of the rainy season, which begins at the Oroonoko about the end of April. The sky becomes obscured, the azure disappears, and a grey tint is spread uniformly

over it;—at the same time the heat progressively increases; and soon, dense vapours cover the heavens from one end to the other. The plaintive cry of the howling monkies begins to be heard before the rising of the sun. The atmosphere is at length convulsed by frequent thunder-storms, the rains descend in torrents, and the rivers, rising rapidly above their banks, overspread the plains with extensive inundations.

The occurrence of these periodical rains is capable of being explained in a very simple manner. We have remarked that they always take place in that half of the torrid zone to which the sun is vertical at the time; and that in the northern half they are preceded by the gradual subsidence of the north-easterly breezes, which are followed by calms, interrupted frequently by stormy winds from the south-east and south-west. While the north-east breeze blows with all its strength, it prevents the atmosphere over the equinoctial lands and seas north of the equator from being saturated with moisture. The hot and moist air rises above, and the north-east current continually supplies its place with colder and drier strata. In this way, the humidity of the northern torrid zone, instead of being accumulated and forming condensed vapours, ascends, and flows towards the temperate regions; and, accordingly, while the north-east breeze retains its force, which is when the sun is present in the southern signs, the sky is constantly serene. In proportion, however, as the sun passes over the equator towards the tropic of Cancer, the north-east breeze softens, and by degrees entirely ceases, because the difference in temperature between the northern temperate and the torrid zone is then at its least. The breeze having ceased, the humid air is no longer replaced by drier air from the north; under the powerful action of a vertical sun, the vapours rapidly accumulated, till they at length descend in violent rains. This state of things continues till the sun re-enters the southern signs; then is the commencement of cold in the temperate zone, and the current from the north sets in again,—because the difference between the warmth of the equinoctial

and that of the temperate regions daily increases. By this current the air of the northern torrid zone is renewed; the rains cease, the vapours disappear, and the sky resumes its clearness and serenity of aspect.

These remarks are principally intended to refer to the seasons in the northern part of South America; but, with certain exceptions, they may very nearly be applied to those of the whole torrid zone—of course bearing in mind that, south of the equator, the rainy season is from October to April, and that the *south-east* corresponds to the *north-east* breeze of northern countries. The period of commencement of the rains is not exactly the same everywhere; and there are places where great anomalies are occasioned by the existence of chains of mountains which attract the vapours and alter the direction of the winds. In the West Indies, and also on some parts of the American continent, *two* wet seasons are distinguished; one of these, however, is of much shorter duration, and has much lighter rains than the other. In India, the rains are brought on by the south-west monsoon.

The four seasons which we distinguish in this country are known only in the temperate zones. Their succession is the most regular and perceptible from the 40th to the 60th degree of latitude; but in this we speak of Europe only, for both in America and Asia a much shorter intervals separates the heat of summer from the cold of winter. That part of the northern temperate zone, which lies between the tropic of Cancer, and latitude 35°, has, in many places a climate resembling that of regions within the tropics. In Europe, even as high as the 40th degree, the frost in the plains is neither intense nor long-continued; the trees are not stripped of their foliage above two months in the year, and although snow sometimes falls at the level of the sea, even in the 37th degree (at Malaga, for example), it is an occurrence very unusual.

From the 60th degree of latitude to the pole, only two seasons take place. A severe and protracted winter is succeeded immediately by the warmth of summer.

The rays of the sun, notwithstanding the obliquity of their direction, produce powerful effects, because the great length of the rays is favourable to the accumulation of heat. Even in very high latitudes, the tar on the ship's sides is sometimes melted and made to run down by the sun's action. In the north of Europe the snow is generally dissolved in three or four days, and the flowers almost immediately begin to blow. The breaking up of the thick field of ice which is annually spread over the surface of the arctic ocean, commences in the month of June, and at this season dense fogs are very common, owing to the surface of the water being colder than the air lying over it. These at length disperse and a short interval of fine weather ensues; but, before the close of August, the approaches of winter are perceived; snow falls; and, as the temperature of the atmosphere declines more rapidly than that of the sea, fogs, called the *frost-smoke* again arise, which disappear only when the ice has begun to extend itself over the clear spaces of the ocean. It is worthy of remark that, even in the circumpolar regions, the west of Europe still maintains its superiority of temperature over the east of North America: for the sea off North Cape in Norway, though in the 72d degree of latitude, is always open, whereas several degrees further south, off the shores of America, it is annually frozen over.

## CHAPTER IV.

## ON THE DISTRIBUTION OF VEGETABLES AND ANIMALS.

### SECTION I.

**Vegetation of the different Zones—Primitive centres of Vegetation.**

The subject of physical climate is in itself highly interesting; but it becomes still more so when we extend our view, and consider its effects upon the numerous animal and vegetable tribes which are dispersed over the

earth. This dispersion has not been the result of a blind and unmeaning chance; the same wisdom which called them into such beautiful and various existence, has fixed laws for their distribution over the surface of the globe. To these laws (without entering into details which belong to botany and zoology) we shall now direct our attention.

The wide extension of vegetable life furnishes one of the most striking examples of the productive power of nature. Every climate, as we pass from the equator to the pole, or from the plains just raised above the level of the ocean to the summits which are covered with eternal snow, has its peculiar vegetation. Countries, the most inhospitable are locked up in frost nearly all the year, are not entirely destitute of it. On Melville Island (N. lat. 75°), where the duration of winter is nine or ten months, and the mean annual temperature only two degrees above zero, there are places which produce, in abundance, moss, lichen, grass, saxifrage, poppy, the dwarf willow, and the sorrel which is so valuable for its anti-scorbutic qualities: the expedition under Captain Parry observed, in a sheltered spot of this island, a ranunculus in full flower in the second week of June. It is thought that even perpetual snow may be the abode of a species of vegetation; for Sausure discovered in it a reddish dust, and a red colouring matter has frequently been observed in snow by navigators in the arctic regions*.

* Captain Parry, in his Narrative of the attempt made in the year 1827 to reach the North Pole, mentions some striking examples of this appearance.—"In the course of this day's journey, we met with a quantity of snow, tinged, to the depth of several inches, with some red colouring matter. This circumstance recalled to our recollection our having frequently before, in the course of this journey, remarked that the loaded sledges, in passing over hard snow, left upon it a light rose coloured tint, which, at the time, we attributed to the colouring matter being pressed out of the birch of which they were made. To-day, however, we observed that the runners of the boats, and even our own footsteps, exhibited the same appearance; and on watching it more narrowly afterwards, we found the same effect to be produced, in a greater or less degree, by heavy pressure, on almost all the ice over which we passed, though a magnifying glass could detect nothing to give it this tinge. The colour of the red snow, which occurred only in two or three spots, appeared somewhat different from this, being rather of a salmon than a rose colour, but both were so striking as to be the subject of constant remark." This colouring substance has generally been thought to belong to the order *Algæ*.

The absence of light does not altogether prevent vegetable existence; caverns and mines produce certain plants, principally those of the cryptogamous class. In the cave of Caripe, situated to the south-east of Cumana in South America, the seeds, which are carried in by the nocturnal birds called Guacharoes, spring up at the distance of several hundred yards from the mouth of the grotto, wherever they can find mould to fix in. Blanched stalks, with some half-formed leaves, rise to the height of more than two feet; but M. Humboldt, who observed them, could not ascertain the species of these plants, their form and colour being so much changed by the absence of light. Vast fields of marine plants spring from the depth of the ocean, especially towards and within the tropics; the vine-leaved fucus vegetates at the depth of 200 feet, and, notwithstanding, has leaves as green as those of grass. In the Atlantic, between the 23d and the 35th degrees of latitude, and in the 29th and 30th of longitude, the fuci float on the surface in such numbers as to give the appearance of an immense inundated meadow. It is supposed, by many botanists, that they grow at the bottom of the sea, and float only in their ripened state, when torn off by the motion of the waves or otherwise.

Extreme heat is not destructive of vegetation, provided that it be accompanied by humidity. Plants grow, not only on the borders of hot springs, but even in the midst of waters which we should have supposed to be quite unsuited to their existence. Examples of this sort occur in Ireland and many other countries. Even sulphureous exhalations are not fatal to vegetation: it is reported that the interior of the crater of Vesuvius, after a long period of repose, was in 1611 covered with shrubs. The greatest obstacle to it is the absence of moisture; those sandy tracts where rain seldom or never falls, and where the soil is constantly being shifted by the winds, exhibit a hopeless sterility. The verdure of the *oases*, or islands of vegetation, scattered over some parts of the African desert, is maintained by springs which rise up to the surface of the ground. The chemi-

cal nature of the soil influences the size and vigour of plants rather than sets limits to their cultivation. Common salt, however, dissolved, and scattered over the earth in large quantities, almost entirely prevents their growth. The fusion which lava undergoes is probably the reason why the progress of vegetation on its surface is so long retarted; whereas, from the ashes thrown out by volcanos, the most abundant crops are raised.

The scale of atmospherical heat is that which ordinarily determines the character and progress of vegetation. Hence, under the fierce climate of the torrid zone, we need only ascend lofty mountains, to a certain height, in order to behold the trees, fruits, and flowers of the temperate zone; while still higher are found those of the frigid zone. The low vallies of the Andes, towards the equator, are adorned with bananas and palm-trees, while the elevated parts of the chain produced oaks, firs, and several other tribes common to the north of Europe. Near the equator, the oak grows at an elevation of 9200 feet above the sea, and never descends lower than one of 5500 feet; but, in the latitude of Mexico, it is seen as low as 2600 feet. From the height of about 15,000 feet, to the boundary of perpetual congelation, lichens are the only plants visible. Similar gradations, on a smaller scale, are observed among the Alps; on ascending which, chesnuts, beeches, oaks, and pines occur in succession, the last gradually becoming stunted till they disappear not far from the border of perpetual snow. The vegetation which covers the sides of mountains may be divided into distinct zones or bands, each zone containing its peculiar tribes. On the volcano of Teneriffe, one of the Canary Islands (N. lat. 28½°), as many as five of these zones are distinguished*:—(1) the region of *vines*; (2) of *laurels*; (3) of *pines*; (4) of the *retama* (an alpine broom); and (5) the region of *grasses*. These zones are arranged in stages, one above another, and occupy, on the declivity of the Peak, a perpendicular height of 11,200 feet.

In the equinoctial region where, in respect of warmth,

* Humboldt's Personal Narrative, vol. i.

the seasons differ little from each other, the geographical distribution of plants is regulated almost entirely by the mean temperature of the whole year; but in the temperate zone this distribution depends not so much upon the mean temperature of the year as upon that of the summer season. In Lapland, there are fine forests on the continent at Enontekies, where the mean annual temperature is only 27 degrees, while on the island of Mageroe, where it is more than 32 degrees, only a few scanty shrubs are to seen. The more vigorous vegetation of Enontekies is the effect of a warmer summer; the mean temperature of July being there 59½°; whereas, at the isle of Mageroes, it is only 46¾°. Some plants in summer require a certain degree of warmth only for a short period; for others, a more moderate warmth is sufficient, if it be of longer duration. The birch and the pine afford an example of this difference. The former tree does not put forth its leaves till the temperature has risen to about 53 or 54 degrees; and in all places where the mean summer heat falls short of this, the birch cannot flourish, however great may be the mildness of the winters. Such is the case on the island just mentioned, and in other parts of Lapland. The pine, on the contrary, requires a long rather than warm summer. In the interior of Lapland, where the summer, though short, is warm, the birch rises much nearer the line of perpetual congelation than the pine; but in the Alps and other high chains in lower latitudes, where the summer is of longer continuance but colder, the pine is seen after the birch has entirely disappeared.

The frigid zone contains but few species of plants, yet of these the vegetation in summer is extremely rapid. The verdure of those countries, which lie within the polar circle, is confined chiefly to the hills having a southern aspect, and the trees are of very diminutive growth. Besides mosses and lichens, there exist ferns, creeping plants, and some shrubs yielding berries of an agreeable flavour. The arctic regions of Europe are peculiarly favoured; for, in certain parts of Lapland, there are fine forests, and even rye and leguminous plants are produced.

In the high latitudes of the northern temperate zone are the pine and the fir, which show their adaptation to a cold climate by retaining their verdure in the midst of the rigours of winter. To these, on advancing southward, succeed the oak, the elm, the beech, the lime, and other forest trees. Several fruit trees, among which are the apple, the pear, the cherry, and the plum, grow better in the northern half of this zone; while to its most southern part especially belong the more delicate fruits, such as the olive, the lemon, the orange, and the fig; and, amongst trees, the cedar, the cypress, and the cork.

The space, comprised between the 30th and the 50th parallels of latitude, may be considered as the country of the vine and the mulberry. Wheat extends as far north as the 60th degree; oats and barley a few degrees further. In the southern part of this zone, maize and rice are more commonly cultivated.

The vegetation of the torrid zone is characterised by a wealth, a variety, and a magnificence, which are nowhere to be found in the other regions of the globe. Under the beams of a tropical sun, the most juicy fruits and the most powerful aromatics arrive at perfection; and innumerable productions supply the wants and administer to the luxuries of man. There the grounds yield the sugar-cane, the coffee-tree, the palm, the bread-tree, the pisang, the immense baobab, the date, the cocoa, the vanilla, the cinnamon, the nutmeg, the pepper, the camphor tree, &c. &c. In South America, is the remarkable tree called the *cow-tree*, which, when incisions are made in its trunk, yields abundance of a glutinous and nourishing milk*. There are also various

* Humboldt, in the 4th vol. of his Personal Narrative, has given an account of this tree. The fecundity of nature in the torrid zone strikingly appears, when we consider the circumstances under which this vegetable milk is produced. "On the barren flank of a rock grows a tree with coriaceous and dry leaves. Its large woody roots can scarcely penetrate into the stone. For several months of the year, not a single shower moistens its foliage. Its branches appear dead and dried; but when the trunk is pierced, there flows from it a sweet and nourishing milk. It is at the rising of the sun that this vegetable fountain is most abundant. The blacks and natives are then seen hastening from all quarters, furnished with large bowls to receive the milk, which grows yellow, and thickens at its surface."—*Personal Narrative*, vol. iv. pp. 216 and 217.

sorts of dyewood, and several species of corn peculiar to hot climates; while this zone is not destitute (in its elevated tracts) of every kind which grows in the plains of temperate countries.

Under the equator, the climate best suited for the culture of all kinds of European grain lies between the altitudes of 6,000 and 9,000 feet above the level of the océan. Wheat will seldom form an ear below the elevation of 4,500 feet, or ripen above that of 10,800. With respect, however, to the lowest height at which corn can be raised between the tropics, there are great irregularities, which tend to prove that the augmentation of heat is not prejudicial to its cultivation, unless attended with an excess either of drought or of moisture. In the environs of La Victoria, a town of Venezula (lat. 10¼° N.), fields of corn are seen mingled with plantations of sugar-canes, coffee, and plaintains, at the height of not more than from 1,700 to 1,900 feet above the sea. The district of Quatro Villas, in the interior of the island of Cuba, furnishes a still more remarkable example; there, fine harvests are raised almost at the level of the ocean. In nearly the same latitudes, on the other side of the Mexican Gulf, the fine fields of wheat are generally between 3,800 and 7,700 feet of elevation; while on the slope of the mountains of Mexico and Xalapa, vegetation, even at the height of 4,320 feet, is so luxuriant that wheat does not form ears. It is erroneous to suppose that grain degenerates in advancing towards the equator, or that the harvests are more abundant in northern climates. On the contrary, it has been found that nowhere to the north of the 45th parallel of latitude is the produce of wheat so considerable, as it is on the northern coast of Africa, and in America, on the table-lands of New Grenada, Peru, and Mexico*. Near the town of La Victoria above-mentioned, the average produce is three or four times as great as that of northern countries.

* The mean temperature for three months of summer is, in the north of Europe, from 59° to 66°; in Barbary and in Egypt, from 80½° to 84°; and within the tropics, at between 8950 and 3840 feet of height, from 57° to 78°.

It is equally large at Buenos Ayrés in the 35th degree of south latitude.

The vegetable forms near the equator are in general more majestic and imposing, and the varnish of the leaves is more brilliant. The largest trees are adorned with flowers, larger, more beautiful, and more odoriferous than those of herbaceous plants in our zone. It is scarcely possible for an inhabitant of temperate regions to picture to himself the beauty and the grandeur of the vast forests of equinoctial America. Trees which attain a stupendous height and size are covered with profusion of climbing plants, and the same lianas as creep on the surface of the earth reach the tops of the trees, and pass from one to another at the height of more than a hundred feet. By this continual interlacing of parasite plants, the botanist is often led to confound the flowers, the fruits, and leaves which belong to different species. M. Humboldt gives the following striking description of the woods on the bank of the Cassiquiare, on approaching the point where that river branches off from the Oroonoko. "The luxuriousness of the vegetation increases in a manner of which it is difficult, even for those who are accustomed to the aspect of the forests between the tropics, to form an idea. There is no longer a beach: a palisade of tufted trees forms the bank of the river. You see a canal 200 toises (426 yards) broad, bordered by two enormous walls, clothed with lianas and foliage. We often tried to land, but without being able to step out of the boat. Toward sunset we sailed along the bank for an hour, to discover, not an opening (since none exists), but a spot less wooded, where our Indians, by means of the hatchet and manual labour, could gain space enough for a resting place for 12 or 13 persons."

A large proportion of the trees of these majestic forests are more than 100 feet in height; while some, especially of the palms, have an elevation of 150 to 200 feet*. Various instances are recorded of the enormous

* Such is the force of vegetation exhibited by American plants in every zone, that in the latitude of 57° N., on the same isothermal line with St. Petersburgh and the Orkney Islands, the Canadian Pine (*Pinus Canadensis*) display trunks above 150 feet high, and more than six feet in diameter.

growth of trees in tropical climates. Humboldt measured on the banks of the Atabapo, a bombax ceiba more than 120 feet high, and 15 feet in diameter. Near the village of Turmero, which lies to the south-west of the city of Caraccas, is the famous *Zamang del Guagre*, a species of mimosa, known throughout the province for the great extent of its branches, which form a hemispherical head more than 600 feet in circumference. The height of its trunk is about 63 feet, and its thickness between nine and ten. The branches extend like an immense umbrella, and bend towards the ground, from which they remain at an uniform distance of 12 or 15 feet. The circumference of the head is so regular, that M. Humboldt traced different diameters, and found them 204 and 198 feet in length. The dragon-tree (*dracæna*) at Oratava, in the island of Teneriffe, is another specimen of enormous growth. Its trunk is about 50 or 60 feet high, and its girth near the roots almost 48 feet. Its average girth is stated by M. de Borda to be 35 feet, 9 or 10 inches. The baobabs are of still greater dimensions than the above. At Senegal, and in the islands of Cape Verd, some were remarked which had a circumference of from 56 to 60 feet, and in another part of Africa one was seen whose diameter was 34 feet (more than 100 in circumference.)

The distribution of plants cannot be explained solely by the influence of climate or by the distribution of temperature; for it frequently happens that similar climates are found in different parts of the globe without identity of productions. The climate of the high mountains of the torrid zone is analogous to that of our temperate zone; yet Humboldt did not discover one indigenous rose-tree in all South America, and it also appears that this shrub is entirely wanting in the southern hemisphere. The genus *erica* (heath is quite peculiar to the Old World;) of the 137 species known, not one is to be met with in the new continent. They seem to be very rare even in Asia. On the other hand, the *cactus* (Indian fig) is confined to the New World. It is true that a similarity exists in respect to their vegetation between

very distant countries, where the physical circumstances are alike; but in some instances it is only a general resemblance of the vegetable forms. In many cases the same *genera* recur; but there are comparatively few examples in which identical *species* have been recognized in countries far remote from each other*. Species of pine, beech, elm, &c. are found in America, differing, however, from the Asiatic and European species. "The lofty mountains of equinoctial America (says M. Humboldt) have certainly plaintains, valerians, arenarias, ranunculusus, medlers, oaks, and pines, which from their physiognomy we might confound with those of Europe; but they are all *specifically different*." The Antarctic birch (*betula Antarctica*) of Terra del Fuego corresponds to, but does not exactly resemble the dwarf birch (*betula nana*), of Northern Europe.

According to M. Humboldt, the species of plants at present known amount to 44,000. Of these, 6,000 are *cryptogamous*†. The remaining 38,000 *phanerogamous* ‡ plants are thus distributed:—

| | |
|---|---|
| In Europe | 7,000 |
| Temperate regions of Asia | 1,500 |
| Asia, within the tropics and islands | 4,500 |
| In Africa | 3,000 |
| Both the temperate regions of America | 4,000 |
| In America, between the tropics | 13,000 |
| New Holland, and the islands of the Pacific | 5,000 |

He also states the proportions of plants which grow in latitudes 0°, 45°, and 68°, to be as the numbers 12, 4, and 1. The mean annual temperatures in these latitudes are respectively 81½°, 55½°, and 32½°, and the mean summer temperatures 82½°, 70°, and 53½°. Within the tropics, the *monocotyledonous* § plants are to the *dicotyledonous* ‖, as 1 to 6; between the latitudes 36° and 52°, as one to 4; and at the polar circle as 1 to 2. The *annual* monocotyledonous and dicotyledonous plants in the temperate zone amount to one-sixth of the whole

* For an explanation of the terms *genus* and *species*, see page —.
† Having neither blossoms nor visible fructification.
‡ Having visible organs of fructification.
§ Having only one coteledon or *seed lobe*.
‖ Having two *seed lobes*.

phanerogamous class; in the torrid zone they scarcely form one-twentieth, and in Lapland one-thirtieth part. A circumstance worthy of remark is the extreme rarity of the *social* plants between the tropics, that is, of those plants which, like the heath of Europe, live together and cover large tracts of land*. In the torrid zone, they are found only on the sea shore and upon elevated plains.

Among the vegetable forms there are some which become more common from the equator towards the poles, as the ferns, the heaths, and the rhododendrons; others, on the contrary, increase from the poles to the equator, among these are the *rubiaceæ*†, the *euphorbiæ*, and the leguminous plants; while others, such as the *cruciferæ* ‡, the *umbelliferæ*§, &c. attain their maximum in the temperate zone, and diminish towards the equator and the poles. The vegetable forms present (under the same *isothermal lines*) such constant relations, that when upon any point of the globe we know the number of species belonging to one of the great families, both of the whole number of phanerogamous plants, and the number of species composing the other vegetable families, may be estimated with considerable accuracy.

It has been a question discussed among philosophers, in what way the various vegetable tribes were originally diffused over the surface of the earth. *Three* different hypothesis have been maintained upon this subject. The *first* supposes that there was only one primitive centre of vegetation; all species of plants having had their existence originally confined to one tract of the earth, whence they were gradually dispersed over all countries.

This hypothesis was adopted by the celebrated Lin-

* Through Jutland, Holstein, Hanover, Westphalia, and Holland, a long chain of hills may be traced, entirely covered with common heath, and the *erica tetralix*. Very little success has attended the efforts made by the farmers to oppose the inroads of these plants.

† One of Jussieu's natural orders of plants, so named from *rubia* (madder.)

‡ An order of plants, so named from their petals, four in number, being disposed in form of a *cross*.

§ Having an *umbella* or *umbel*. This term is used to disignate a particular mode of flowering, which consists of several flower stalks, or rays, nearly equal in length, spreading from a common point or centre. The flowers of the hemlock and parsley are *umbellate*.

naæus. He imagined the habitable world to have been at the commencement limited to one spot, in which were collected the originals of all the species of plants, together with the first parents of all animals and of the human race. As such various natures would require a diversity of climates for their support, he supposed this tract to have been suited in a warm region, and to have contained a lofty mountain range, between the base and the summit of which were to be found all temperatures and climates, from the temperature and climate of the torrid to those of the frigid zone. Linnaæus endeavoured to support this hypothesis by referring to the means which are provided for the multiplication and dispersion of plants. Winds, rivers, and marine currents, are all, more or less, instrumental in the conveyance of seeds from one country to another. The former carry the lighter kinds of seeds to immense distances, and the two latter sometimes transport others from the most remote parts. The naturalist just mentioned remarks that the *Erigeron Canadense* was first introduced into the gardens near Paris from Canada; the seeds being scattered by the wind, this plant was, in the course of a century, spread over all France, Italy, Sicily, Belgium, and Germany. The migration of plants by means of currents is also well ascertained, and many instances of it are recorded. On the shores of the Hebrides are collected at times the seeds of the *mimosa scandens, dolichos urens,* and several other plants of Jamaica, the isle of Cuba, and the neighbouring continent. These are not the only methods in which the dispersion of species is effected: it is also known that some seeds (as the misseltoe and juniper) are capable of preserving their vitality in the stomachs of birds, and are thus propagated. Lastly, man has introduced various plants into countries where they previously had no existence.

The *second* hypothesis is, that each species of plants originated in and was diffused from a single primitive centre; but that there were several of these centres situated in different parts of the globe, each centre the seat of a particular number of species. The *third* and

last hypothesis is, that wherever a suitable soil and climate existed, there the vegetable tribes sprang up; and that plants of the same species were, from the first, spread over different regions.

We proceed to relate some facts which have been observed, and which will enable us to form some opinion as to which of the three preceding hypothesis has the best foundation. The greater number of these facts are taken from the opening part of Dr. James Prichard's work, entitled "Researches into the Physical History of Mankind," where they are brought forward in a similar discussion to the present.

Those plants whose structure is the most simple are found to be very generally diffused. Among the cryptogamous tribes, (such as mosses, lichens, &c.) which form the lowest order of the vegetable creation, the same species are often met with in the most distant regions*. Two-thirds of the lichens observed in Australia, are also natives of Europe; and of the ferns of New Holland, which constitute rather more than 100 species, twenty-eight have been discovered in other countries. Many of the monocotyledonous tribes are also widely spread. Several grasses are common to Europe and Australia. In South America too, only the mosses, but likewise several grasses, are the same as European species. It is not so, however, when we view the distribution of the more perfect, or of the dicotyledonous plants, there being a very small number of such, which are common to countries distant from each other. With respect to the dicotyledonous tribes, Humboldt has maintained that all the indigenous kinds in those parts of America visited by him are peculiar to that continent, and that the only exceptions to this rule are plants of the sea-coasts, the migration of which is easily to be explained. The ob-

* To explain the extensive diffusion of these species, Linnæus supposed that their seeds, being invisible particles, might be carried to incalculable distances by the winds. It may, however, be remarked, that in the less perfect tribes of plants, the specific distinctions, not being so strongly marked as in the more complex forms, may escape detection; and thus two plants found in distant places may be set down as of the same species, when there is really some minute difference between them.

servations of Mr. Brown on the botany of Terra Australis (*Southern Land*) tend nearly to the same point. Of the plants already known in that country, 400 species are cryptogamous, 861 monocotyledonous, and 2,900 dicotyledonous. Of the 400 cryptogamous, more than 120, that is nearly *one-third* part, are also indigenous in Europe. Of the 860 monocotyledonous, only 30, or about *one twenty-ninth* part, have been found in Europe, and more than half of these are grasses and *cyperoids*. But of the 2,900 dicotyledonous species, only 15 or about the *one hundred and ninety-third* part, are the same in Australia as in Europe. Results no less striking have been obtained on comparing the vegetation of other southern countries with that of Europe and the northern regions. Though the proportion of European plants in Australia is so small, it appears to be greater than that which is observed in the south of Africa. The proportion of European species in South America is probably still less than it is in Southern Africa.

From the preceding remarks, it is to be gathered, that the most simply organized tribes of plants are very widely dispersed; that plants of the more perfect or more complex forms are, on the contrary, limited to particular countries; and that the monocotyledonous, which may be considered as tribes of an intermediate class, are neither so extensively spread as the former, nor confined within such narrow limits as the latter.

Some exceptions to this general rule have lately been brought to light by the botanical discoveries made during the expedition to the river Zaire on the west coast of Africa (about 6° S. lat.) From Mr. Brown's observations upon upwards of 600 plants collected in the neighbourhood of that river, it appears that about one-twelfth of the collection consists of species, which are also met with either in India, or on the opposite shores of Guyana and Brazil; and it is a curious fact, that in this number the *more perfect plants are in the greatest proportion.* This apparent anomaly is probably to be explained by the transportation of seeds from one shore to another by means of currents in the inter-tropical seas. Mr. Brown

remarked that most of those plants in the African collection which are also natives of other countries, were seen only on the lower parts of the river Zaire, where they bear but a small proportion to the whole vegetation: and that most of the dicotyledonous species are such as produce seeds capable of retaining the germ of life during a long immersion in the waters of the ocean.

It will be proper in this place to mention the phenomena belonging to the vegetation of islands. In small islands the most remote from continents the species of plants are very few, and sometimes quite peculiar. Thus in Kerguelen's land, or the island of Desolation, when visited by Captain Cook, the whole flora was found to contain only 16 or 18 plants, all of which were considered to be peculiar to the island. Not a shrub was seen in the whole country. The flora of islands, as far as it is not peculiar to them, generally consists of the same species which grow on the nearest main lands. The different groups seated in the great Southern Ocean which lies between America and Eastern Asia serve as an example; the easternmost islands contain more plants of American families or species, and the western, of those tribes peculiar to India. Islands placed in the neighbourhood of two continents comprise the vegetation of both. Malta and Sicily have plants which belong to Europe, and others of an African stock. The vegetation of the Cape de Verd islands is intermediate between the flora of the Canary isles and that of the African coast.

The facts which have been introduced in the course of this inquiry forbid us to adopt the hypothesis of Linnæus, which considers all plants to have originated from one common centre. The propagation of the several tribes of plants has certainly taken place from a number of different points; since, of various parts of the world, separated by vast distances, each possesses a vegetable kingdom in a great measure peculiar to itself. The third hypothesis to which we allude is equally untenable: since it is seen that plants are confined to particular tracts, till their seeds are conveyed elsewhere. Numerous instances have occurred in which plants by trans-

portation have acquired a new country, and there become abundant; a striking example of this kind is the dispersion of the *Erigeron Canadense* over Europe, which we have already related. This shows that in the first instance, plants of the same species were not produced in all regions possessing a soil and climate suitable for their growth. We have also seen that, when the same species are observed to exist in countries widely separated, the circumstances generally are such as authorized us to infer that they were dispersed from one point. The only hypothesis which remains, and which is reconcileable with all the phenomena observed, is that the vegetable creation was originally divided into different provinces, and that each country (probably each principal range of mountains) had its peculiar tribes which, at first, existed nowhere else. This conclusion is strengthened by the circumstance of particular plants having an entirely local and insulated existence, growing naturally on some particular mountain, and nowhere else. The cedar of Lebanon is one among several examples of plants of this description. Such instances alone might be deemed conclusive in favour of the hypothesis for which we have been arguing.

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## Section II.

**On the distribution of Animals—their original dispersion from distinct centres.**

In the ascent from the vegetable to the animal world, and from one rank of animal existence to another, the most admirable order is manifest. We are not surprised by sudden steps or encountered by violent contrasts; an evident connection pervades the whole; and though there is a vast diversity when we compare the meanest specimen of organic life with its most perfect and majestic forms, yet between the two an harmonious chain may be traced, and we pass from one extreme to the other by a regular and scarcely perceptible gradation.

The lowest class is that of the *zoophytes* (plant animals), which raise up the coral islands spoken of in a

former part of this book. They may be regarded as confused masses of beings, none of them endued with a separate life. Nevertheless, there is reason to believe, from the observations of MM. Person and Lesueur, that each description of zoophyte has its place of residence determined by the temperature requisite for its support. The *molluscæ*, whether naked or covered with shells (*testaceous*)*, possess each an individual existence, and of these it is unquestionable that different species belong to different countries. The pearl oyster arrives at perfection only in the equatorial seas.

*Insects* are the next in the scale of animal existence. In the midst of the exuberant vegetation of the torrid zone, the largest and the most splendid of these tribes are to be seen; the butterflies of Africa, of the East Indies, and of America, are adorned with the most brilliant colours; and in the tropical forests, especially those of South America, millions of shining flies present at night almost the appearance of an extensive conflagration. In these countries some races of insects exist in such multitudes, and are armed with such destructive or venomous qualities, as to enable them to lay waste the fruits of the earth through large tracts of country, or to become a source of the most serious personal annoyance and discomfort to man. The white ants (*termites*) raise lofty hillocks; and where they much abound, have been known to excavate the soil to such a degree, as to endanger the safety of houses which happen to stand above the seat of their operations. They devour paper and parchment so rapidly, that whole provinces of Spanish America (Humboldt informs us) do not afford one written document that dates a hundred years back. The *mosquitoes* and other species of the family of *tipulæ* are also formidable enemies to the human race in these climates. Amidst the forests of South America, especially along the banks of particular rivers, there are large tracts

* The term *testaceous* is in strictness applied only to such fish as have a strong, thick, and entire shell; those which have shells, soft, thin, and consisting of several pieces joined together, as the lobster, &c., being called *crustaceous*.

which are almost uninhabitable, owing to the thick swarms of these insects and the unceasing torment which they occasion. The lower strata of air to the height of nearly 20 feet from the ground are sometimes so filled with them as to give the appearance of a condensed vapour. During the day, the atmosphere teems with the *mosquitoes*, which are small venomons flies; these are succeeded, at night, by a species of gnats called *zancudoes*. The distribution of these insects is very remarkable, and frequently depends on local circumstances which cannot be explained. They are, in general, found to shun those rivers which have what the Spaniards call black waters (*aguas, negras.*), and also dry and unwooded spots. They swarm most upon the banks of rivers, and they nearly disappear where the elevation of the ground exceeds two or three thousand feet above the sea*. The annoyance occasioned by insects of this description is not confined to the torrid zone; for even in the Arctic regions of Greenland and Lapland, the short heats of summer give birth to swarms of gnats of another species.

With respect to *fishes*, it is probable that every basin of the ocean has its particular tribes: while, indeed the regions which some inhabit are well known. Thus the cod, which are distributed over all the northern seas between Europe and America, congregate chiefly upon the great sand-banks to the south-east of Newfoundland. The most remarkable species of fish are met with in the torrid zone and its vicinity. The flying fish hardly extends to any part of the ocean so high as the 40th parallel; but in the voyage to America, hundreds of them are seen by navigators after passing the tropic of Cancer. The Largest and most powerful of those fish which possess electrical properties, also live within the torrid zone. The Mediterranean contains four species of electrical torpedoes; but the shocks which they communicate cannot be compared in voilence to those of the *gymnoti* (electric eels), which inhabit several of the

* Humboldt's Personal Narrative, vol. v., p. 86—116.

rivers, and also the stagnant pools, in the llanos of South America. All the inhabitants of the waters dread the society of these animals. It is related that, some years ago, it became necessary to change the direction of a road near Uritucu, in consequence of the number of mules of burden annually lost in fording a river in which eels were very numerous. The temperature of the waters in which the gymnoti habitually live, is from 78 to 80 degrees: their electric force is said to diminish in colder waters.

The seas of the warm regions contain the shark, which is noted for its extreme ferocity; but the most enormous in size are the whale tribes, which belong more particularly to the high latitudes.

The migration of fishes seems to be occasioned by their seeking for shallow water, in order to deposit their spawn. The herrings, which are supposed to come from the bottom of the Arctic Ocean, proceed every year to the coasts of the British islands, Norway, Sweden, Denmark, Holland, and the United States; and also to those of Kamtchatka and the neighbouring islands. The opinion is, that their innumerable shoals follow the direction of the chains of sub-marine banks and rocks which they meet with in their progress. Tunnies also migrate regularly every year from the Atlantic Ocean to the Mediterranean.

The hot regions of the globe, and those of America in particular, contain the largest and the most venomous of the order of *reptiles*, including the rattle-snake, and several other kinds armed with deadly poisons; and the boa constrictor, which destroys even the great quadrupeds by the force with which it coils round their bodies. Here, too, the lizard tribe, under the various names of crocodiles, gavials, aligators, and caymans, attain to an immense growth. The largest is the crocodile of the river Nile, which measures, when full grown, even thirty feet in length. It is worthy of remark, that the dry season near the equator has the same effect upon several of the reptile race as the cold of northern countries: in South America, when the swelling of the rivers subsides, and

the surface of the llanos becomes parched by the heat, boas and crocodiles bury themselves beneath the mud, and await, in a state of lethargy, the periodical rains. As we proceed into the higher latitudes, reptiles diminish both in number and magnitude, and are, even the worst of them, comparatively harmless.

With respect to *birds*, we might at first be inclined to infer from the powers of locomotion with which they are gifted, that the existence of each species is not limited to a certain region; and it is true that some of them, including several of the vulture tribe, spread themselves almost over the whole world. But it appears to be generally the case, that particular kinds are confined to a very small range, especially such as have heavy bodies and weak powers of flight Even the *condor*, which frequently soars at an elevation of four miles, never forsakes the chain of the Cordilleras of Peru and Mexico; and the great eagle does not quit the ridges of the Alps. The torrid zone possesses a variety of the most beautiful birds, including the humming-birds of America, the cockatoos, the bird of Paradise, the lories, and several others of the parrot genus. The bird of paradise is never met with beyond New Guinea and the neighbouring islands. Parrots, in the New World, are seen as high north as the 35th degree; but on the old continent, they do not appear to reach farther than the 28th parallel. Of the birds which cannot fly, each equatorial region insulated by the ocean has its particular kinds. The ostrich of Africa and Arabia, the cassowary of Java and of New Holland, and the Brazilian ostrich, are distinct species, possessing a general similarity of organization.

The frozen zone has its own kinds of birds, among which are the *strix Laponicus* (Lapland owl), and the *anas mollisima* (eider duck), which frequents the shores of the Arctic seas and from whose nests the eider-down is obtained. The several species of *sea-birds* do not wander beyond certain limits assigned to each. The albatross is seen flitting along the surface of the waves, as we approach the 40th parallel of latitude. The sea-swallows and the tropical birds keep within the torrid

zone. The penguin of the Northern differs from the manchot of the South Seas.

The migration of birds from one country to another, in consequence of the changes of the seasons, is a remarkable phenomenon. The direction and extent of these migrations are still, in most cases, but imperfectly known. On the approach of winter, swallows, storks, and cranes abandon the northern countries of Europe for the warmer climates of the south. In the equinoctial zone, which is nearly of the same warmth during the whole year, the variations of drought and humidity appear to influence the habits of animals in the same manner as the great changes of temperature in our climates. In South America, when the Oroonoko begins to swell with the rains, an innumerable quantity of ducks remove from eight and three degrees of north, to one and four degrees of south latitude, towards the south-south-east. These birds quit the valley of the Oroonoko at this period, doubtless because the increasing depth of the waters and the inundations of the shores prevent them from catching fish and insects. In the month of September, when the Oroonoko decreases and retreats within its bed, they return from the Amazon and the Rio Branco towards the north. The southern coasts of the West India islands also receive every year, at the season of the inundations of the great rivers of terra firma (the continent,) numerous flights of the fishing birds of the Oroonoko, and of its tributary streams. It is in obedience to a similar instinct, that, during the heats of summer, the humming birds advance in pursuit of insects into the northern parts of the United States, and even into Canada.

*Quadrupeds* are an order of animals more perfectly organized than any of those which have been under consideration; while, as they are in many instances immediately connected with man, and altogether come more under his observance, their distribution presents a more ample subject for investigation. The hot regions towards the equator furnish this order in the utmost number and variety; and many of its tribes are there

distinguished for their size, their amazing strength, or the feriocity of their dispositions. The lion, the tiger, the elephant, the rhinoceros, the hippopotamus, the panther, the leopard, the hyæna, and the camelopard, are all inhabitants of the torrid zone and its vicinity. In the temperate regions, the animals are of much smaller dimensions; and the only beasts of prey are the wolf, the bear, the lynx, and the wild boar; but there the domestic tribes are reared in all their perfection. The white or Polar bear, which is quite different from the common bear and much more formidable, inhabits the coasts of the Arctic Ocean; so that, under both extremes of temperature, the animal creation assumes a character of exessive ferocity.

The *domestic* animals have been conveyed by man to various parts of the world, and are therefore very widely dispersed. Under this title are included the dog, the cow, the sheep, the goat, the horse, the ass, the pig, and the cat. Humboldt states (contrary to what has been supposed by some), that the cows in the equinoctial parts of South America will yield as rich a milk as in temperate countries. The ass is not capable of enduring cold so well as others of the domestic races: when beheld in the northern regions of Europe, he is quite a degenerate animal: south of the 40th parallel of latitude, under the influence of a more genial climate and better treatment, he is large, lively, and docile. The horse, originally a native of the central parts of the old continent, is now spread from the confines of the Arctic Circle to beyond the 50th degree of south latitude. It exists as high as Norway and Iceland, where it is small and of a peculiar variety, and extends even into the desolate regions of Patagonia. This animal was introduced into South America by the Spaniards, in their early visits to that continent; it has since greatly multiplied, and immense herds now rove wild over the llanos. The existence of these creatures is exposed to the most severe sufferings. "In the rainy season," says M. Humboldt, "the horses that wander in the savannah, and have not time to reach the rising grounds of the llanos, perish by hundreds

amidist the overflowings of the rivers. The mares are seen, followed by their colts, swiming, during a part of the day, to feed upon the grass, the tops of which alone wave above the waters. In this state they are pursued by the crocodiles; and it is by no means uncommon to find the prints of the teeth of these carnivorous reptiles on their thighs.

"We cannot reflect," he proceeds, "on the effects of these inundations, without admiring the prodigious pliability of the organization of the animals that man has subjected to his sway. In Greenland, the dog eats the refuse of the fisheries; and, when fish are wanting, feeds on sea-weed. The ass and the horse, originally natives of the cold and barren plains of Upper Asia, follow man to the New World, return to the savage state, and lead a restless and painful life in the burning climate of the tropics. Pressed, alternately, by excess of drought and of humidity, they sometime seek a pool in the midst of a bare and dusty soil, to quench their thirst; and at other times flee from water, and the overflowing rivers, as menaced by an enemy that encounters them on every side. Harassed during the day by gadflies and mosquitoes, the horses, the mules, and cows find themselves attaked at night by enourmous bats*, that fasten on their backs, and cause wounds which become dangerous because they are filled with acaridæ, and other hurtful insects. In the time of great drought, the mules gnaw even the thorny melocactus (melon-thistle), in order to drink its cooling juice; and draw it forth as from a vegetable fountain. During the great inundations, these same animals lead an amphibious life, surrounded by crocodiles, water-serpents, and manatees. Yet, such are the immutable laws of Nature, their races are preserved in the struggle with the elements, and amid so many sufferings and dangers. When the waters retire, and the rivers return into their beds, the savannah is spread over with a fine odoriferous grass; and the animals of old

* In Brazil, in the province of Ciara, the bats cause such destrnction omong the cows, that rich farmers are said from this cause to be sometimes reduced to indigence.

Europe and Upper Asia seem to enjoy, as in their native climate, the renewed vegetation of spring."

It has been observed by Buffon, that the largest quadrupeds, such as the elephant, the rhinoceros, the hippopotamus, the camelopard, the camel, and most of the ox kind, are possessed exclusively by the old world. In America, the *fossil* remains of some large animals have been discovered; but of living species, there are very few of considerable bulk. It has also been remarked, that the tribes which are the most powerful and perfect in their structure belong chiefly to the old world; those of the new having, in general, a character of organization which assigns them a lower rank in the scale of animated beings. Such carnivorous animals, for example as have the greatest vigour and courage (among which are the lion, the tiger, and the hyæna) are confined to Asia and Africa. The American tribes which approach most nearly to these, are, in general much more gentle and feeble than the African and Asiatic species. It must be admitted, however, that Buffon's assertion respecting the cowardice of the feline race of America must be taken with some limitation: for it appears that the jaguar will sometimes attack men; and, when assailed by armed numbers, he has been known to offer an obstinate resistance. The swiftest, as well as the most graceful and beautiful quadrupeds (the antelopes, for example) also chiefly belong to the old continent; while those kinds which are the most useful to man, including the goat, the horse, the ox, and the ass, were unknown in America till their introduction into that country by the Spaniards.

Confining our view to wild animals, we may divide the earth into a number of zoological regions or provinces, each of which is the residence of a distinct set of quadrupeds*.

The first of these provinces, if we commence from the north, is the Arctic region, which contains the white bear, the rein-deer, the Arctic fox, and other tribes

* See Dr. Prichard's ·· ks, before mentioned.

common to both of the great continents. The circumstance of their being common to both continents is accounted for, by the communication which, during winter, is established between the shores of Asia and America by means of the ice, over which a passage from one to the other becomes practicable to such animals as are fitted to endure the intense cold of the circumpolar countries.

The northern temperate zone is divided by the ocean into two great districts. The same tribes are found to be spread from the western to the eastern parts of the old continent; but the quadrupeds which inhabit the temperate climate of America are peculiar races.

The equatorial region contains three extensive tracts, widely separated from each other by the sea. These are the intertropical parts of Africa—of America—and of continental India. Each of the three tracts in question has a distinct nation of quadrupeds. The Indian isles, particularly the Sunda and Molucca islands may also be considered as a separate region.

Beyond the Indian Archipelago is Papua, under which name it is usual to include New Guinea, New Britain, and New Ireland. These countries, with the islands which are formed by a continuation of their mountain chains, namely, the archipelago of Soloman's Islands. Louisiade, and the New Hebrides, together with the more remote groups in the great Southern ocean, may be regarded as one zoological province. It is remarked, that all this extensive region seems almost wholly destitute of native warm-blooded quadrupeds, except a few species of bats, and some small domestic animals in the possession of the natives.

The large region of Australia forms another zoological province, in which are contained many indigenous tribes of a very singular description; and, lastly, the southern extremities of America and Africa are each distinguished by the possession of peculiar races.

Of these several provinces, into which the animal world admits of division, none is peopled with so remarkable a stock of animals as Australia, including, under

that designation, New Holland, and the adjacent islands to the southward. It possesses several entire genera of quadrupeds which have been discovered in no other part of the world; and it further deserves notice, that most of the tribes peculiar to New Holland, though on the whole very different from each other, have some striking characters of organization common to all. It was assumed by Linnæus, that the great class of worm-blooded quadrupeds was, without exception, *viviparous* and *mammiferous*—two terms, the first of which denotes their production of their offspring in a living and perfect state; and the second, their being supplied with organs for suckling their young. On this latter account, it received the name of *mammalia*, by which it is known among naturalists. It appears, however, that, in New Holland, a tribe of warm-blooded animals has been discovered, to which that name is not applicable, because it is *oviparous* (that is, produces *eggs*), and is therefore unprovided with organs of the description above-mentioned. This curious tribe is, as far as our present knowledge extends, quite confined to New Holland. Another remarkable tribe is the *marsupial*, which term comprises such as produce their young in an immature state, and keep them for a time attached to their bodies, chiefly in abdominal *bags* or *pouches*, given them by nature for that purpose. This Tribe also is met with principally in New Holland. One genus of it, indeed, the opossum or didelphis, is peculiar to the warm parts of America, and some species of phalangers are seen in the Moluccas; but over the Australian regions there are distributed several genera of the marsupial order, comprehending more than 40 species. Among these are the wombat, the langaroo-rat, the kangaroos, and the dasyuri or Australian opossums.

The didelphis, or American opossum, differs from the Australian opossum in several respects; one of which is the having a long prehensile or muscular tail, which serves as a fifth limb, and is of great use to animals which inhabit forests so extensive and lofty as those of

Guyana*. In the same part of America there are other animals which resemble the opossum in this respect: these are the sapajous, a numerous tribe of monkeys, the ant-eaters, the kinkajou, and the hystrix prehensilis (prehensile porcupine). Herein we behold striking instances of the structure of animals being fitted to the nature of the country in which they reside. The monkeys of Africa and of India are distinguished by no such peculiarity, for in those parts of the world it is not requisite.

We have already mentioned that the new continent is, compared with the old, nearly destitute of the most powerful and perfect tribes of quadrupeds. In their place are found most of those singular races, in the formation of which the ordinary rules of nature seem most widely to have been relinquished. Such are the tribes which Cuvier has termed Edentes, or quadrupeds defective with respect to teeth, some of them being entirely destitute of those organs. Thus America contains the whole family of sloths, the ant-eaters, which are quite unprovided with teeth, and the armadilloes, which have grinding teeth, but no tusks or cutting teeth.

That part of Southern Africa which extends beyond the tropic of Capricorn, forms quite a distinct zoological province, separated as it is by the intervention of the torrid zone, from the milder climates north of the equator. Accordingly the animal creation of this region assumes a character almost as peculiar as that which is displayed by its vegetation. Of the order termed Mammalia, Southern Africa contains several peculiar genera, which occupy various distances towards the north, according to the degree in which they are capable of enduring a hot climate. In many instances the same *genera* are found in this region as in temperate countries north of the equator; but it is particularly to be observed that the Southern *species* differ from the northern. Thus the quagga, the zebra,

* The phalangers of Australia and the Moluccas have the prehensile tail.

and some others of the horse kind answer to the ass and the jiggetai of Asia. From the southern tropic to the Cape of Good Hope, the continent of Africa stretches into fine level plains, over which roam a great diversity of hoofed quadrupeds. Besides five of the horse genus there are also peculiar species of rhinoceros, of the hog and the hyrax; and among ruminating animals, the giraffe or camelopard, the Cape buffalo, and several remarkable antelopes, as the spring bock, the gnou, the leucophœ, and others.

The animals of the Indian Archipelago have in some respects a different character from those of continental India, and approach towards those of Africa. The Sunda isles are said to contain a hippopotamus—an animal which does not exist in the rivers of Asia. The rhinoceros of Sumatra resembles the African more than the Indian species, but is specifically different from both. It is the same with the crocodile tribe, which is divided into three sub-genera; the crocodile proper, the alligator or cayman, and the gavial. The alligator belongs to America—the gavial inhabits the Ganges, and probably other rivers in continental India—of the crocodile proper there are six species, of which some belong to Africa, others to the isles of the Indian ocean, and one is said to have been discovered in the West Indies. Among flying quadrupeds, the flying macauco or lemur, is seen only in the islands of the Indian ocean; two species of flying squirrel, and two remarkable genera of the family of bats, also reside there; besides which some of the flying phalangers are supposed to belong to the Moluccas.

It will be proper, in the next place, to inquire more particularly into the manner in which the most numerous families of quadrupeds are distributed over different parts of the world. In this enumeration, it is of course not intended to include those animals which man has been the means of conveying from one country to another, whence the same species have in some instances become scattered over the most distant parts of the earth.

Most of those animals which Linnæus comprised in his order *Primates*, inhabit warm or temperate climates. The

two grand divisions of this order are the bat and the monkey tribes. The latter has been sub-divided by Cuvier into two chief branches, very different from each other—the simiæ proper, which are confined to the old continent—and the sapajous, which are peculiar to America. The African simiæ are distinguished from the Indian; and most of their species are limited each to a comparatively small tract. In the island of Madagascar, no true simiæ exist, but in their place are the makis, a tribe of lemurs. Of the bat tribe, the rousettes or frugivorous (*fruit-eating*) bats, inhabit the Indian archipelago and Australia, and the vampires, or blood-sucking bats, nine species of which have been mentioned, are all peculiar to the hot parts of America. The most numerous genus of bats are the vespertiliones; some of these are very extensively dispersed, but this is not the case with the majority, and not one species is common to the old and new Continents.

The *feræ*, or carnivorous quadrupeds, properly so termed, are extensively spread, although most of them belong to hot climates. Of the twenty-eight species of the cat kind, which have been enumerated, not one is the same in America and in the Old Continent; even the lynx of Canada is now believed to be a distinct kind from the European. The African species are generally confined to Africa, and the Indian to the eastern side of the Indus. The tiger is found only in Asia, extending as high as Chinese Tartary; but it is by far most common in India, living in ravines and jungles. Africa, although destitute of tigers, possesses panthers and leopards. The lion is most formidable in Africa, where there are two species, the Barbary and the Senegal; it is also said to belong to India, and it inhabits those parts of Arabia and Persia, which border on the Tigris and Euphrates from the Persian Gulf as far as Bagdad. The Arabian species is smaller than the others, and the males have no mane. The *couguar* or *puma*, a native of South and North America, which is sometimes called the American lion, is a different animal from the real lion. Of the dog kind, several species endure an arctic climate, and are com-

mon to the high latitudes of both continents. The *logopus* or *isatis* (arctic fox) is found at Spitzbergen, and may be traced through the north of Asia to Kamtchatka, and thence to the shores of America, Hudson's Bay, and Greenland. The wolf and the *lycaon* (black fox) are also common to all the arctic countries. Others of the dog kind require a warm or temperate climate, and these occupy a limited space either in Asia, in Africa, or in America. The dog of the Falkland island *(canis antarcticus)*, which was the only quadruped discovered there, has by some been considered a separate species, while others have held it to be the same as a species which inhabits Chili.

The *pachydermatous* (thick-skinned) tribes, live only in warm or temperate regions. There exist two species of elephant, the Indian and the African. Of the rhinoceros there are several species, but none of them are possessed in common by Asia and Africa. Those with two horns inhabit southern Africa. Those with one horn belong to India and China, and to some of the islands of the Indian Archipelago. In America, the only representative of these large pachydermatous animals is the tapir. The hyrax and the hog tribes do not extend into cold climates; the wild boar, which ranges further towards the north than any of his tribe, is spread over various parts of Europe, but is never seen to the north of the Baltic. The domestic hog, since its introduction into America, has run wild and formed large herds in that Continent.

Among ruminating animals, the goat, the antelope*, and the giraffe, or camelopard, are limited to the Old Continent; but of sheep, some peculiar species are possessed by America, as, for instance, the paco, which in its domestic state is called bicunua or vigonia, and is an inhabitant of Peru. The camelopard, which is so remarkable for its height, its swan-like neck, and its gentle disposition, is a native of southern Africa. The antelope, of which the species are very numerous, is

* Several American species have been described which are considered to be nearly related to the antelope.

almost confined to Asia and Africa, none of them being found in Europe, except the chamois and the saiga. They inhabit as well the torrid zone as those parts of the temperate zones which are not very remote from the tropics. The dromedary or camel with one hump, is a native both of Africa and Asia; the two-humped or Bactrian camel, so called because it is supposed to have orginally come from Bactriana, belongs to much more northern climates than the other; it lives in the Crimea and in central Asia, in countries where the winter is very severe. The lama, or guanaco, which has been named by some the camel of the New World, is a widely different kind from either of the preceding. The musk resides in the mountains of Asia, from Cashmere, along the Altaï, to the mouth of the river Ameer. This animal is not seen in the New continent, although there are tribes which bear a relation to it. Some species of the deer and ox inhabit very cold climates, and these have passed along the arctic regions from one continent to the other. Those which are unable to support such severe seasons, are confined to certain local tracts in either continent.

We shall conclude our inquiry into the distribution of quadrupeds, with the mention of some facts respecting the description of animals discovered in islands. Small islands lying at a great distance from continents are in general quite destitute of land quadrupeds, except such as appear to have been conveyed to them by men. Kerguelen's Land, the islands of Juan Fernandez, the Gallapagos, &c., are instances of this fact. Among all the fertile groups in the Pacific Ocean, dogs, rats, hogs, and a few bats, are the only quadrupeds which have been seen. The Indian isles near New Guinea, abound in oxen, buffaloes, goats, deer, cats, rats, hogs, and dogs; but according to all accounts, none of these have reached New Guinea, the two latter excepted. In Easter island, the most remotely seated in the Pacific, there are no domestic animals, except fowls and rats, which are eaten by the natives.

The quadrupeds of islands situated in the neighbourhood of continents, are generally the same as those of the

adjacent main-land. This remark may be made respecting the animals of the British and of the Mediterranean isles, as well as of those in Madagascar, and in the islands near New Holland. When in such islands any quadrupeds are met with, which do not exist in the neighbouring continents, they are usually distinct species which occur nowhere else, and either have always had a local existence, or have been entirely destroyed from the main-land.

There is thus reason to conclude, that islands in general derived their quadrupeds from the continents in the neighbourhood of which they are placed.

Having now stated the facts which relate to the distribution of the principal races of animals, it remains only to inquire what inference we are entitled to draw concerning the manner of their original dispersion over the earth; whether that dispersion took place from a single spot, or whether, as in the case of the vegetable tribes, it commenced from a variety of distinct centres.

The local existence of insects is so closely connected with that of the plants which not only yield them sustenance, but also, in many instances, furnish their only place of abode, that we might at once expect to find the same laws prevailing in the dispersion of this part of the animal creation, as in that of the vegetable tribes. This conjecture has been confirmed by positive researches. M. Latreille, by whom the subject has undergone a full investigation, states that the whole or the greater part of the arachnides and insects which inhabit countries of similar soil and temperature, but widely distant from each other, consist in general of different kinds. All the insects and arachnides which have been brought from the eastern parts of Asia, under whatever latitude, are distinct from those of Europe and of Africa. It further appears, that with insects, as with plants, where the species are different, the *genera* are nevertheless often the same. In this manner, the entomology of America approximates to that of the Austral countries, and the east of Asia. The insects of New Holland are often of the same genera with those of the Moluccus, and the south-eastern parts of India; they show much affinity to

those of New Zealand and New Caledonia, and, as just observed, include similar genera of those of America: yet the entomology of New Holland is, notwithstanding, marked by a peculiar character. A large number of insects are found near the Cape of Good Hope, which are unknown in other countries: M. Lichtenstein collected there between 600 and 700 species, of which 340 were ascertained to be entirely new.

In adverting to the dispersion of the various tribes which inhabit the waters of the ocean, including the marine mamalia, as well as fishes and molluscæ, it is to be remarked that, in the descriptions of these tribes, great vagueness and inaccuracy has long prevailed. Therefore it is that this department of the animal kingdom contains so many species which are said to inhabit indiscriminately all parts of the ocean. The common whale (*balæna mysticetus*) has been supposed to belong equally to the frozen seas of Spitzbergen and to those of the antarctic circle. The sea-calf (*phoca vitulina*) is reported by several writers to be a native not only of both circumpolar regions, but also of the seas of the torrid zone; while some have gone so far as to assert that it exists in the Caspian, and even in the fresh-water lakes of Baikal, Onega, and Ladoga. But the fact of such extensive dispersion of marine animals rests entirely on the authority of incompetent persons. The celebrated naturalists Lesueur and Pérun who personally collected and examined a vast number of marine species in the southern hemisphere, have come to the conclusion, that the arctic ocean does not contain one tribe, well known and described, which is not *specifically distinct* from those animals most analogous to it in the antarctic seas. This remark applies not only to the cetaceous and phocaceous tribes, but also to the lower departments of marine animals; and, descending through a variety of worms and molluscæ, even to the shapeless sponges of the antarctic waters, these naturalists assert that, among all this immense assemblage, not one species will be found which exists in the seas of the northern hemisphere. It further appears that those maritime animals, which possess little

power of self-extension, prevail within very narrow limits. Each species of the family of *medusæ* is seen in abundance in particular districts, and occurs in no other place. It is the same with the numerous *testacea* which adorn the shores of the southern seas. The shores of Timor present a great multitude and variety of beautiful testacea; but not one of these extends so far as the southern coast of New Holland.

With respect to reptiles, birds, and quadrupeds, the fact already stated concerning their distribution are sufficient to show that different regions of the world are each in possession of peculiar kinds. Many entire genera are wholly confined to certain districts; but when, as it frequently happens, the same genus is discovered among the wild and native animals of two distant regions, to a communication between which natural obstacles are opposed, it is not the same *species* that inhabit both countries, but corresponding species of the same *genus*. Thus the American species of the cat kind differ from the African and the Asiatic; and the species of horse, ox, antelope, rhinoceros, and elephant, of Africa, are distinct from those of the same genera in Asia.

Under the circumstances, we can arrive at no other conclusion than that the first dispersion of animals, like that of vegetables, took place for divers points. It is probable that, at least, each of the great mountainous chains and table lands was originally furnished by the Creator with a stock of animals. The offspring of each species have since spread themselves to as remote a distant from the first spot of their existence as their locomotive powers, their capability of bearing changes of climate, or the absence of physical obstacles to their further progress, may have allowed them to wander.

## SECTION III.

On man in his Physical Character—His universal Dispersion over the Earth—Unity of his Species—Terms Genus and Species explained. Varieties of the Human Race, and manner in which they may be accounted for—Influence of Climate.

The physical character of man, although it be not such as to exempt its possessor from those laws of generation, of growth, and of dissolution, which prevail among the inferior tribes of animals, is nevertheless of a peculiar and pre-eminent kind. His organization, more perfect and complex than theirs; his erect and noble aspect; his form, better suited for rendering obedience to the impulses of a rational and intelligent mind;—all essentially distinguish him from the brutes over whom he exercises dominion. Under such circumstances as these, it is not a little surprising that there should ever have existed naturalists who pretended to confound the human species with tribes of the lower animal creation.

In some respects it may appear that the organization of man subjects him to great disadvantages; the extreme feebleness of the human frame at the first period of its existence; the slowness of its growth: the multiplicity of its wants; the variety of ills and infirmities to which through life it is exposed, have no parallel among the beasts of the field. Yet who that considers the present moral imperfection of man, can deny the good which results from these physical disadvantages inseparable from his condition? Endued with the strength of the lion or the elephant, or clothed with a skin impervious to cold and moisture, he would probably have remained sunk in selfish indolence, and ignorant of all the arts which embellish life. But the feeling of his wants and weakness has aroused faculties which would else have lain dormant in his mind—has, by uniting him to his fellows, given rise to the most endearing ties and the most useful forms of society; and has so called forth his inventive resources, that he has, to a considerable extent, acquired the command and the direction of the powers of nature.

The researches of modern navigators have shown that

the human race is spread nearly over the whole earth. It has been found in the midst of the most sultry regions, in the vicinity of the pole, and upon islands which a boundless ocean would have seemed to cut off from communication with the rest of the world. The islands of Spitzbergen and of Nova Zembla to the *north*, and Sandwich Isle, the Isles of Falkland, and Kerguelen's Land to the *south*, are the only countries of considerable extent which have been found entirely destitute of human inhabitants. In the north, the habitations of man stretch nearly to the 75th degree of latitude; while to the south a miserable race (that of the Petcheres) exists on the bleak and barren shores of Terra del Fuego. The oases, or islands of verdure, scattered over the sands of Africa, are also the seats of population. In one part of the world the human body supports a heat higher than that which makes ether boil; and, in another, a cold which occasions the congelation of mercury.

Notwithstanding the dissimilarities of structure and complexion which are observed upon comparing the natives of different countries, there are the strongest reasons to believe that the human race forms not only a single *genus*, but also a single *species*; or, in other words, that all the several varieties of men sprung originally from one pair of individuals. Though there exist independent grounds for this opinion (as will presently be shown,) it is proper, before we proceed to a statement of these, to remark that the whole tenor of Revelation is against any other supposition.

We may discern in the difference between the means adopted for peopling the earth with the human race, and those provided for covering it with the inferior creatures, the traces of that wisdom which uniformly pervades that arrangement of Providence. Had there been, in the first instance, no more than one pair of each genus of animals, and one individual of each tribe of plants, and had these been called into being upon only one spot of the earth, large regions separated by wide seas and lofty chains of mountains from the country containing that single spot, would for ever have remained almost, if not entirely,

destitute of plants and animals, unless at the same time means had been provided for their dispersion far more effectual than any which we behold in operation. To prevent a result so little in harmony with what appears to be the general system of the universe, each separate region of the globe was supplied with a distinct stock of plants and animals. But in the instance of the human race, such a plan of proceeding was not requisite. Man was endued with a constitution capable of accommodating itself to the greatest changes of climate, and with the power of inventing methods for protecting himself against atmospheric influence: he was also enabled, by the aid of the same power of invention, to transport himself over the most extensive seas and across the most formidable ranges of mountains. Furnished with these capabilities, his race was originally placed in only one spot of the world.

In order that the question may be fully understood, it is requisite to explain what is signified by the terms *genus* and *species*, of which frequent use has been made in the course of the present treatise. A race of animals, or a tribe of plants, marked by any peculiarities of structure, which from one generation to another have always been constant and undeviating, form a *species*; and two races are held to be *specifically distinct*, if they are distinguished from each other by some pecularities, which, in the lapse of generations, the one cannot be supposed to have acquired, or the other to have lost, through any known operation of physical causes: so that, under the word species, are comprised all those animals which are concluded to have sprung, in the first instance, from a single pair*. The term *genus* has a more extensive application. There are several species which so resemble each other as immediately to suggest the idea of some near relation between them. The horse, the ass, the zebra, and others of the horse kind, are one instance of this remark, the different species of elephants are another;

* It is certainly possible that what we term one species may have sprung from two or more original pairs *exactly alike*; but judging from all that has been observed, it is by no means probable.

and a third is furnished by the several kinds of oxen, buffaloes, bisons, &c., all belonging to the ox genus, and bearing a striking resemblance one to the other. As no physical causes are known which could have operated so as to produce those differences of structure, which exist between the several species of one genus, it is concluded that they originally sprung from different individuals. A *genus*, consequently, is a collection of several species on a principle of resemblance; and it may, therefore, comprise a greater or less number of species, according to the particular views of the naturalist. It is not, however, always easy to determine what races of animals are of the same, and what of separate species. It is a well known fact, that considerable varieties arise within the limits of one species; and such varieties are often transmitted to the offspring, and become, in a great measure, permanent or fixed in the race. Hence the difficulty, in some cases, of deciding whether two races of animals, of the same genus, and similar in many particulars, but differing in others, are merely what are termed *varieties* of one species; their diversities having proceeded from the action of external, or other causes, on a stock originally the same; or tribes of an entirely distinct origin from the beginning.

Dr. Prichard, in an able work entitled "Researches into the Physical History of Mankind," to which we have before had occasion to refer, mentions the criteria which may be used in order to determine whether all the races of men belong to the same species. The first of these is furnished by a reference to the general laws of their animal economy: since, should it appear that, in two races of animals, the duration of life is the same; that their natural functions observe the same laws; that they are subject to the same diseases, and susceptible of the same contagions—there is a very strong presumption that they are of the same species. Another way of examining the subject, is to inquire whether the diversities in mankind are strictly analogous to those varieties in form, colour, &c., which occur in the lower departments of the animal creation, within the limits of the

same species. The method, however, which bears most directly upon the question, is to ascertain what is positively known respecting the springing up of varieties among the human race.

First, with respect to the laws of the animal economy. it may be inquired whether there any peculiarities which distinguish one race of men from another, of such a description as to render it probable that they constitute distinct species. Certain writers have supposed that there is a difference between Europeans and some other nations, in the duration of life. It is not to be denied savage nations are in general, shorter lived than the inhabitants of civilized countries; but this circumstance is sufficiently explained by their addiction to intemperate habits, and their constant exposure to fatigue and hardships. When they have not such disadvantages to contend with, their term of life seems to be as long as that of any other race of men. Several instances are cited, both of negroes in the West Indies, and of native Africans, having attained to a very advanced age; and among the natives of America, cases of longevity are far from uncommon. Humboldt mentions the name of a Peruvian who lived to the age of one hundred and forty-three, and who, only thirteen years before his death, was accustomed to travel on foot from three to four leagues daily. The Laplanders, again, are said to be rather remarkable for long life.

As to diseases, it seems an undoubted fact that all human contagions, and all epidemic complaints, exert their pernicious influence on every tribe of men, though the natives of particular climates suffer more than others. And so to constitutional complaints, the difference is only one of predisposition, and analogous to what is witnessed in different families in the same nation, some being constitutionally more liable to certain disorders than others. The constitution of the American is observed to be the most torpid, that of the European in general the most irritable.

The conclusion which results from the first method of inquiry, as will be more particularly seen by referring to

the work above-mentioned, is, that the grand laws of the animal economy are the same in their operation upon all the races of mankind. The deviations which occur are not greater than the common varieties in constitution which exist within the limits of the same family. Here, then, is one strong presumption in favour of the inference that all men belong to one species; for it appears that, among animals, neighbouring species, so closely allied as to have often been taken for mere varieties of the same stock (as the wolf and the dog), differ materially in the laws of their animal functions.

The next mode of inquiry suggested, is, how far the diversities of complexion, figure, and stature, seen among the several races of men, are analagous to those varieties which, in the inferior animals, often occur without marking any specific difference, and, indeed, originate before our eyes within the limits of the same species. In this place we shall accordingly note the most remarkable instances of variety which appear in mankind.

One, and that the most obvious to common observers, is the *diversity of colour*. It is well known that there is a correspondence between the colours of the skin, the hair, and the eyes of individuals. With few exceptions, light-coloured eyes are joined to a fair complexion and light hair, but a relation of the colour of the skin to that of the hair is perhaps universal. The women of Barbary and Syria are said to be often very white, although they have black hair; but this is to be attributed to art, and careful protection from the sun. Dr. Prichard, taking the hue of the hair as the leading character, divides mankind into *three* principal varieties of colour, which he calls the *melanic*, the *xanthous*, and the *albino*. The first includes all individuals or races who have *black* hair; the second, those who have either brown, auburn, *yellow*, flaxen, or red hair; and the third, those who have *white* hair, and who are also distinguished by red eyes. "The *melanic* variety forms by far the most numerous class of mankind. It is the complexion generally prevalent; except in some particular countries, chiefly in the northern regions of Europe and Asia, where races of the xanthous variety

have multiplied; and it may be looked upon as the natural and original complexion of the human species. The hair of the head, in the melanic races, is of various texture and growth, from the long and lank hair of the native Americans, to the fine crisp hair of the African negroes. The hue of the skin varies from a deep black, which is that of some African nations, to a much lighter or more dilute shade. The dusky hue is combined, in some nations, with a mixture of red, in others with a tinge of yellow. The former are the copper-coloured nations of America and Africa; the latter, the olive-coloured races of Asia. In the deepness or intensity of colour we find every shade or gradation, from the black of the Senegal negro, or the deep olive and almost jet black of the Malabars and some other nations of India, to the light olive of the northern Hindoos. From that we still trace every variety of shade among the Persians and other Asiatics, to the complexion of the swarthy Spaniards, or of European brunettes in general." Examples of the *albino* variety have been noticed in almost all countries. In Europe they are by no means uncommon; sixteen instances have been seen in Germany by Professor Blumenbach. The fact of their occurrence in other parts of the world is also fully established. It appears that they are frequent among the copper-coloured native Americans on the isthmus of Darien; and they have been observed in many islands both of the Indian and the great Southern Ocean. Among the Hindoos they are regarded with peculiar horror. The most remarkable circumstance, yet not an unusual one, is the birth of white negroes among the black races of Africa: they are looked upon as curiosities, and are often collected by the native monarchs. Their hair is of a woolly character, and many of them are true *albinos*. The *xanthous* variety may be considered as intermediate between the other two. It chiefly prevails in the temperately cold regions of Europe and Asia, where it sometimes runs through whole tribes; but it also springs up out of every melanic race. The Jews, like the Arabs, are generally black haired, but many may be seen with light hair and eyes; and the same remark

will apply to the Russians. The xanthous variety also appears among the South Sea islanders and the natives of America, and even among the negro races of Africa, both in their own climate and in the places to which they have been transported.

*Varieties of form*, more especially of the *shape of the skull*, furnish another grand instance of diversity among the races of men. The ingenious Professor Blumenbach has made the varieties in the construction of the skull the basis of a division of mankind into five principal races or departments, which he denominates, 1. the Caucasian; 2. the Mongolian; 3 the Ethiopian or Negro; 4. the American; and 5. the Malay and South Sea Island*. The *first* is that variety to which the nations of Europe and some of the western Asiatics belong; in this class the head is almost round, and of the most symmetrical shape, the cheek bones without any projection, the face oval, and the features moderately prominent. In the *second* class, the head is almost square, the cheek bones projecting *outwards*, the nose flat, the face broad and flattened, with the parts imperfectly distinguished, the internal angle of the eye depressed towards the nose. In the *third* class, the head is narrow and compressed at the sides, the forehead very convex, the cheek bones projecting *forwards*, the nostrils wide, the jaws lengthened, the skull in general thick and heavy, the face narrow, projecting towards the lower part, the nose spread and almost confounded with the cheeks, the lips particularly the upper one, very thick. The *fourth* variety approaches to the Mongolian: the cheek-bones are prominent, but more arched and rounded than in the skull of the Mongole, the form of the forehead and of the top of the head is often altered by means of artificial pressure during infancy, the face is broad without being flat, the forehead low, and the eyes deeply seated. In the *fifth* variety, the summit of the head is slightly narrowed, the forehead a little arched, the upper jaw somewhat projecting, the face less

* The first three are the most strongly marked varieties in the form of the skull; the remaining two being only approximations to the preceding.

narrow, and the features more prominent and better marked than in the negro.

These descriptions give a clear idea of five principal varieties in the form of the human head; nevertheless, the attempt to assign them as the distinctive characters of so many races of men is open to strong objections; since, whether we take as a standard the figure of the skull, or perhaps any other peculiarity of structure, it is impossible, with reference to that standard, to divide the human species into departments, such as can be regarded with probability as so many separate races of families. The third, or Ethiopian variety of skull, is found in the greatest degree among the tribes inhabiting the coast of Guinea and other western countries of Africa; but it must not be set down as common among all the Negro nations; for there are many black and woolly-headed races in Africa which come under the designation of Negro, who display a very different shape of the head and features from that described under the *third* variety. Again, the skulls of the New Hollanders are almost as much compressed as those of any Negroes, and they would, under the preceding classification be brought within the Ethiopic race; yet no one could assert that the New Hollanders and the woolly-headed Africans, differing so much in other physical characters, and separated by so vast a distance, should be included in the same department of the human species. On this account, Dr. Prichard has proposed a division of the varieties of the skull into three classes, distinguished by names derived from their forms, and not from any supposed origin of the nations to which they respectively belong.

In the *shape of the body*, as well as in the *size and proportion of the limbs*, and consequently in the degree of strength and agility which they possess, there are some remarkable varieties among nations. Some Negro tribes, the Australian or New Holland savages, and the Kalmucks, seem to be those which differ most in figure from Europeans. According to numerous measurements, the arm below the elbow is somewhat longer in the Negro,

in proportion to the upper arm, and to the height of the stature, than it is in the European. It has therefore been been remarked, that in this respect the generality of Negroes approach more to the structure of the ape; but if we descend to individuals, many Europeans will be found in whom the fore arm is as long as in the majority of Negroes, and, on the other hand, Negroes in whom it is as short as in the majority of Europeans. A clumsy form of the legs, broad and flat feet, and large hands, are also described as peculiarities of the Negro.

With respect to *stature*, the difference between one nation and another is generally not very considerable. From all accounts, the tallest race of men existing are the Patagonians. They are usually more than six, and, in some instances, as much as seven feet in height. On the contrary, the natives of Terra del Fuego are described as miserable and puny savages. The Esquimaux, in the north of America, are likewise diminutive, being generally under five feet. Africa also contains some small races. Of the Bosjesmans or Bushmen, who are said to be the most deformed of mankind, Lichtenstein saw two individuals who were scarcely four feet high. The unhappy race, who were plundered of their property and hunted down like wild beasts by the early settlers in the Cape colony, have since lived among the rocks and woods on the northern frontier of the settlement, where they support themselves in a great measure by depredation. These instances tend to show that when whole races are deformed and stunted, it is to be attributed to exposure to constant hardship, or an inclement climate, and to the wretched and precarious nature of their subsistence. Both extremes of stature which have been observed among nations, are frequently surpassed by individual examples in the inhabitants of different countries. Many natives of Europe, from eight to nine feet high, have been exhibited as objects of curiosity, and there have been dwarfs of less than four, and even three feet.

The only other varieties in the human race which require notice, are those in the *texture of the skin*, and

*the character of the hair.* The skin of Negroes is said to be always cooler than that of Europeans in the same climate, and to be distinguished for its sleekness and velvet-like softness. A similar observation has been made of several African tribes, and also of the Otaheitans. These qualities of the skin seem to be connected with the existence of the dark matter by which, among these nations, it is coloured; for in *albinos*, both African and Otaheitan, the skin becomes rough and inflamed, and cracks upon being exposed to the sun. The contrasts between the hair of different races are exceedingly striking. In the Negro, the Hottentot, and some other races, the hair is short and crisp, somewhat approaching to the nature of wool; in other nations it is long and lank; and between these two kinds there are numerous gradations. In Africa, Kaffers have hair like that of the Negroes; some tribes have it longer; some again, who are black and otherwise similar to Negroes have hair curled, but not crisp. The Papuas (the name by which the inhabitants of New Guinea and the neighbouring islands are distinguished) have crisp hair; but, unlike that of the Africans, it grows very long, and admits of being spread out into an immense bush. The hair of the natives of Van Diemen's Land is as crisp as that of the Africans, but the New Hollanders have straight hair; while in the New Hebrides it is of an intermediate character, and varies considerably in the men of the same island. The hair of the natives of America is generally lank; in a few instances curled; but in none crisp or woolly

In the next place, we shall compare the diversities, of which a sketch has been given, as existing in the appearance of the human race, with the variations in form, colour, and structure, which are seen in the lower animals, and especially in the domesticated kinds. The differences in colour which quadrupeds of the same species exhibit, are so familiar to the eye, that it is unnecessary to do more than allude to them. Among horses, oxen, dogs, cats, rabbits, &c., we continually behold hues which are analogous either to the melanic, the xanthous, or the albino varieties in mankind. Among several kinds of

wild animals, a white not unfreqnently springs up. In many instances, certain colours are prevalent in particular breeds, and in some cases we might be warranted in concluding that the colours depend upon the local circumstances of the countries in which the breed is placed, Blumenbach mentions several examples which will illustrate this remark. He states that all the swine of Piedmont are black; those of Normandy, white; and those of Bavaria of a reddish brown colour. In Hungary, the oxen are of a greyish white; in Franconia, they are red. The turkeys of Normandy are black; those of Hanover almost all white. In Guinea, the dogs and the gallinaceous* fowls are as black as the human race. Even in our own country, certain colours may be seen prevailing in the cattle of particular districts. Doctor F. Buchanan says, that in Mysore, the sheep exhibit three sorts of colour: red, black, and white, and these are not distinct breeds. Don Felix de Azzara relate some curious circumstances respecting the colour of the horses and oxen in Paraguay, where, as well as in other parts of South America, both these races have run wild, and become very numerous. He says that all the *wild* horses are of one colour (a chesnut or bay-brown), whereas the domestic horses are of all colours, as in other countries. He makes a similar kind of observation concerning the oxen. As to form and the structure and proportion of parts, the diversities which arise in the same race of animals, far surpass those which subsist between one nation and another among men. Alluding to the hog tribe, Professor Blumenbach remarks, that "no naturalist has carried his scepticism so far as to doubt the descent of the domestic swine from the wild boar. It is certain that before the discovery of America by the Spaniards swine were unknown in that quarter of the world, and that they were first carried thither from Europe. Yet notwithstanding the comparative shortness of the interval, they have in that country degenerated into breeds wonderfully different from each other, and from the original stock.

* From *gallus* a cock.

These instances of diversity, and those of the hog kind in general, may therefore be taken as clear and safe examples of the variations which may be expected to arise in the descendants of one stock." He afterwards observes that the difference between the craniums of the Negro and of the European is not greater than that between the craniums of the wild boar and of the domestic swine. In the breeds of oxen, sheep, and horses, we may discern additional examples of deviation from an original standard. Some breeds of sheep and oxen are destitute of horns; others, on the contrary, are distinguished by the large size of their horns. In Paraguay there are breeds of oxen without horns, descended of the common horned race. With respect to horses, Blumenbach again observes that there is less difference in the form of the skull in the most dissimilar of mankind, than between the elongated head of the Neapolitan horse and the skull of the Hurgarian breed, which is remarkable for its shortness and the extent of the lower jaw. The varieties in the covering of animals are not less worthy of notice than those to which reference has already been made. In the same race of sheep, some are clothed with wool, others with hair. It is known that if a flock is neglected, the fine wool is succeeded by a much coarser growth, intermixed with strong hairs; the breed, being no longer kept up with care, seems gradually to degenerate towards the characters of the *argali*, or wild sheep of Siberia, which naturalists consider to be the stock whence all domestic sheep have proceeded. A striking specimen of the changes which occur in breeds is afforded by the sheep of the West India islands, which, although descended from the woolly sheep of Europe, are covered with coarse hair. The deterioration has usually been attributed to the heat of the climate; but it must also be referred to the circumstances of their breed having been neglected. Other animals, such as goats and dogs, display a similar variety in the nature of their covering.

The preceding facts clearly prove that, in the lower animal creation, there spring up, *in the same species*, varieties of an analogous or similar kind to those which

mark the different races of men. The existence of this analogy confirms still further the opinion expressed as to the unity of the human species. It now only remains to inquire whether it is absolutely known that varieties have arisen in a family or race of men similar to those diversities which distinguish one nation from another.

It is a well-attested fact, that, among negroes and other dark-coloured tribes, individuals of the albino and xanthous complexions are not unfrequently born; and with respect to form and structure, and the texture of the skin and hair, many instances are recorded wherein surprising peculiarities have made their appearance in a race or family, and some in which these have been transmitted to descendants. The description of such cases would exceed the limits of the present treatise; but an account of several may be seen by referring to the author* whom we have already cited.

It appears, therefore, that if we apply to the subject under discussion the several criteria stated at the outset of this inquiry, the results, every one, lead to the inference that the various nations of the globe are descended from the same stock. This inference is drawn, *first* from the observed uniformity in the grand laws of their animal economy, allowance, of course, being made for the effects of climate and of particular habits; *secondly*, from the existence in the same species among the inferior tribes of the creation, of varieties analogous to those which occur in mankind; and *thirdly*, from the fact of varieties being really known to have sprung up among men, more or less similar to those which distinguish different nations. There is, nevertheless, a point at which the similarity between the two cases obviously terminates: the peculiarities which arose in the the human species at a remote and unknown period have become the characteristic marks of large nations, whereas those which have made their appearance in later times, have, in general, extended very little beyond the individuals in whom they first showed themselves; and certainly have never at-

* Dr. Prichard's 'Researches into the Physical History of Mankind.'

tained to anything like a prevalence throughout whole communities. But this is a circumstance which it does not seem difficult to explain, if we consider that, ever since the population of the world has been of large amount, the possessors of any peculiar organization have borne such a very small numerical proportion to the nation to which they belonged, that it is no way surprising that they should soon have been lost in the general mass, still less that they should have failed to impress it with their own peculiar characters. In the early period of the world, when mankind, few in numbers, were beginning to disperse themselves in detached bodies over the face of the earth, the case was altogether different, and we can easily understand how, if any varieties of colour, form, or structure, then originated in the human race, they would naturally, as society multiplied, become the characteristics of a whole nation. These considerations may suggest to us the *manner* in which the national diversities first obtained their ascendancy. The *causes* of those diversities are, and probably ever will remain, enveloped in mystery; and the inference as to the unity of the human kind is not weakened by our inability to assign those causes, since we are ignorant of the occasions even of the varieties which sometimes display themselves within the limits of a single family.

It will be seen, however, upon a comprehensive survey, that in the distribution of the different races of men there is a certain relation to *climates.* We may observe that the *black* races of men are principally situated within the torrid zone; and the *white* races in the regions approaching towards the pole; and that the countries bordering on the torrid zone are generally inhabited by nations of a *middle* complexion. It further appears that the natives of mountainous and elevated tracts are usually of lighter colour than the natives of the low and hot plains on the sea-coast. In Africa most of the races between the tropics are either black or of a very deep colour; while beyond the tropics the prevailing complexion is either brown or red. The people of Fezzan, who are of a black hue, form an exception to this rule; but it has been

remarked of them, that they are chiefly slave-dealers, and have intermixed with the negro race brought from the interior of Africa. In other countries of the globe, the majority of the nations near the equator are almost black. In India there are black tribes in Malabar; and the Hindoos of the Deccan are generally very dark, as are also the inhabitants of Ceylon. In most of the islands of the Indian ocean, the *aborigines* are of a black colour; and still further eastward are the Papuas of New Guinea, and the black inhabitants of Solomon's islands and the New Hebrides. In equatorial America, the natives are not so dark as in other parts of the torrid zone; but it is elevated mountains, vast rivers, and extensive forests, impart a peculiar character to the climate of the New World, which may probably account for the difference. In the low countries of California it is remaked that the population are nearly as dark as negroes.

It is a very general opinion, that the origin of the diversities of *colour* in mankind is to be referred entirely to the gradual influence of climate and of the sun's rays in darkening the complexion; it being a commonly observed fact, that the skin even of white men, becomes embrowned by constant exposure to the heat. But there are circumstances which militate against this opinion. There is positive testimony that the offspring of individuals, darkened by the sun in hot countries, is born with the *original complexion*, and not with the acquired hue of the parents*; besides which, it is known that white races of men, who have been removed from a cold to a hot climate and have not intermarried with the natives, have retained for ages their original colour; while, on the other hand, black families, when transplanted into more temperate countries, have remained for generations of exactly the same hue as their African progenitors. Dr. Prichard has also remarked that the above supposition is contrary to a general law of the animal economy, according to which, *acquired* varieties† are not transmitted

* Dr. Prichard's "Researches," vol. ii. pp. 532, &c.

† *Acquired* varieties are opposed to those which a person brings into the world at his birth.

from parents to their offsprings, but terminate in the generation in which they have had their origin.

Yet although it seems that the existence of varieties cannot be attributed to the slow and gradual operation of climate upon successive generations, numerous facts lead to the conclusion that there is a natural tendency among races, both of men and animals, to the production of varieties suited in form and constitution to the local circumstances of the country where they arise. Or it may, perhaps, be better explained, in some cases, by supposing that, whatever varieties occur, the ability to establish a footing in any country belongs to those only which possess a constitution adapted to local circumstances. Thus men of the *xanthous* variety of colour are known to spring up among the negroes in Africa; but their constitution being entirely unsuited to the climate, we cannot believe that they would ever become numerous in that continent. In the temperately-cold regions of the world they would be favourably circumstanced; and we accordingly see, that this variety has multiplied there to a considerable extent.

# PHYSICAL GEOGRAPHY OF INDIA.

## CLIMATE, GEOLOGY, AND MINERALOGY.

### CHAPTER I.

CLIMATE.—Himmaleh Region—Middle India—Peninsular India—Height of the Land in the Peninsula—Meteorology—1. Changes in the Pressure of the Atmosphere; 2 Composition of the Atmosphere; 3. Effects of Mountain air; 4. Temperature of the Atmosphere; 5. Making of Ice in India; 6. Snow-line; 7. Height of the Snow-line in the Himmalehs; 8. Evaporation; 9. Humidity of the Atmosphere; 10. Dew; 11. Rain; 12. Monsoons; 13. Hail; 14. Falling Stars and Meteoric Stones; 15. Mirage; 16. Black Colour of the Sky over the Himmalehs; 17. Zodiacal Light; 18. Miasmata; 19. Climate; 20 Sanitary Depôts—Table of Comparative Temperatures.

In the view we are now about to take of it, India may be considered as formed of three grand divisions, viz. 1. The Himmaleh. 2. The belt of flat country extending from the Indus to the Brahmapoutra, which may be distinguished by the name of *Middle India*. 3. The region which constitutes *Peninsular India*.

1. *Himmaleh or Alpine Region.*—The central and interior region of Asia, which forms neither an immense cluster of mountains-chains nor a continued table land, is crossed from east to west by four grand systems of mountains, which have manifestly influenced the movements of the population;—these are, the Altai, which is terminated on the west by the mountains of Kirghiz, the Teen-shan, the Kwan-lun, and the Himmaleh chain. Between the Altai and the Teen-shan, are placed Zungaria and the basin of the Ele; between Teen-shan and

the Kwan-lun, Little or rather Upper Bucharia, or Cashgar, Yarkand, Khoten, the great desert Cobi (or Chamo), Toorfan, Khamil (Hami), and Tangout, that is, the Northern Tangout of the Chinese, which must not be confounded with Thibet or Sefan; lastly, between the Khan-lun and the Himmaleh, Eastern and Western Thibet, where Lassa and Ladak are situated. The Himmaleh system, the only one which at present particularly interests us, separates the valleys of Cashmere, Nepaul, and Bootan, from Thibet. To the west it stretches by Javaher to 26,420 feet; to the east by Dhwalagiri to 27,000 feet above the level of the sea. It ranges generally from north-west to south-east, and consequently is not parallel with the Kwan-lun; it approaches it so nearly in the meridian of Attok and Jellalabad, that between Cabul, Cashmere, Ladak, and Badakshan, the Himmaleh seems to form a single group of mountain-chains with the Hindookho and Tsung-ling.

In those parts of the Himmaleh that form the northern boundary of India, are situated some of the highest mountains in the world. Of these the most elevated summit at present known is Dhwalagiri, or White Mountain, already mentiond. The following are other heights, as determinated by Webb:—

| | feet. |
|---|---|
| Jumnotree, | 25,500 |
| Setghur, or the White Tower, north of Nepaul, | 25,261 |
| A Mountain, supposed to be Dhaibun, above Catmandoo, in the direction of Cala Bhairava, 20,000 feet above the Valley of Nepaul, and above the sea, | 24,625 |
| Another mountain near it, 18,662 feet above the Valley of Nepaul, above the sea, | 23,262 |
| A third, in its vicinity 18,452 feet above the sea, | 23,052 |
| A peak, named St George, was estimated by Hodgson at | 22,240 |

*Mountain Region.*—Interposed between the *Alpine* and *Pestilential Regions* of India is the richest mountain land in the world, the beautiful girdle of Assam, Bootan, Nepaul, Serinagur, Cashmere, and Peshawer. These delightful regions range in altitude upwards of 7000 feet above the level of the sea, rising with a steep ascent from the plains of the low country. According to Ren-

nel, the southernmost of the Bootan mountains attain nearly a mile and a half of almost perpendicular height, in a horizontal distance of fifteen miles; and from the summit the traveller looks back with wonder on the extensive prospect of the plains beneath. When the great range changes to a westerly direction, near the upper part of the Ganges and Indus, the lower mountains are separated from it by a wide interval occupied by the lofty valley of Cashmere; and to the south and south-west is a mountainous country, which on the north bounds the Punjaub or country of the five rivers. When in December, Turner returned from Thibet, then covered with ice and snow, in Bootan every thing was green, and the trees were loaded with apples and oranges,—so great is the difference of climate. Notwithstanding this, the summer temperature of Tassisudon in Bootan resembles that of the winter of Bengal, and the Bootan winter is too severe for the rajahs, who descend and spend that season in the warmer Chickacotta. The Bengalese clothe themselves in silk and muslin; the Bootanese in wool; the Thibetians in wool and fur; and not less characteristic is the contrast between the feeble Hindoo in Bengal and the Herculean Bootanese, or the active, abstemious Thibetian. The Hindoo, accustomed to the moist and sultry atmosphere of Bengal, cannot exist in the cold and dry Alpine air of Thibet, and conversely the Thibetian cannot live in the sultry India.

*Pestilential Region.*—A zone of unequal breadth, of a peculiar nature, lies between the northern mountainous and hilly boundary of India and the low country. It extends from the frontiers of Assam almost uninterruptedly to the banks of the Ganges and Jumna, at Hurdwar and Serinagur. It is thirty miles broad on the Bootan frontier, and here, as elsewhere, is filled with swamps, and covered with a dense and luxuriant vegetation. It forms the natural boundary between Bengal and Assam, Bootan and Nepaul. None of the neighbouring nations have been able to obtain an ascendancy in this melancholy region; for man flies its marshes, which are inhabited principally by amphibious and other offensive crea-

tures; and, where the woods penetrate among the lower hills, numerous herds of elephants range from Assam to Hurdwar. The exhalations arising from the multitude of springs, which the vicinity of the mountains produces, are collected and confined by those almost impervious woods, and generate an atmosphere through which no traveller ever passed with impunity. Its effects were fatal to Captain Jones, and to a great part of his troops in 1772.

*Goître Region.*—The pestilential region is not without inhabitants, though its influence has wholly debased in them the form, the size, and the strength of human creatures. Here the disease named *goître* prevails. From Rungpoor towards Bootan it is estimated that every sixth man has a crop or swelling. It occurs also in Lower Bootan; but Turner saw nothing of the kind in Thibet. The inhabitants of Assam are visited with great goîtres, and also the people of the valleys of Serinagur and those that dwell near the open land of Kemaoon. This disease, conjoined with cretinism, prevails throughout the whole zone, from the borders of Assam, in 27° north lat. and 110° east long., to Hurdwar on the Ganges, in Rohilcund, in 30° north lat. and 78° east long., in those districts bounded on the south by Bijnee, Cooch-bahar, Rungpoor, Dinagepoor, Purnea, Tirhoot, Bettiah, and the northern boundary of Oude through Gooracpore, Baraitseh, Pillibeat, and on the frontier of Rohilcund, through Hurdwar. It extends farther to the westward: Forster met with it on his mountain journey from the Jamboo pass towards Cashmere. Appearances of the same kind occur on the southern border of the Cobi above Pekin, in the Kolla and Magaza in Africa, in the marshy woods of Simbani, in the land of the Mandingoes, in the southern acclivity of the Alps, &c., as dwell in those places where snow-water is wanting as where it is met with,—a fact in opposition to that opinion which ascribes the goître disease to the bad qualities of the snow-water.

2. *Middle India.*—This great comparatively flat region, the richest and most productive part of our eastern empire, comprehends—1. The great tract watered by the

Ganges. 2. The tract watered by the Indus. 3. The intermediate desert.

As this division of India is noticed in a preceding volume of this work, we need not enter into further details, but merely remark that the alluvial tract from Hurdwar to the mouth of the Ganges, may, according to Hindoo speculators, formerly have been occupied by the sea,*—thus giving to the peninsular part of India an insular form; and that the Desert, which in many of its characters resembles strongly the African and Arabian sandy plains, is the eastern portion of the vast series of deserts which stretch from the western boundary of the great Sahara in Africa across the whole of that continent, Arabia, part of Persia, to the west side of the Indus.

3. *Peninsular India.*—The Peninsula of India, which is totally unconnected with the Himmaleh range, is bounded by the waters of the ocean and the plains of Central or Middle India, and forms as it were a world for itself. It is bounded on the north by a mountainous, hilly, and table-shaped country, which includes the mountains extending from the Gulf of Cutch on the west to the Bay of Bengal on the east, viz. those of Guzerat, Malwah, Candeish, and Gundwana. We also, in a geological view, include in this region the mountainous and hilly ranges stretching around the great Western Desert as far as the neighbourhood of Oodipoor, Ajmere, Jypore, to Delhi. On the south-west and southeast it is bounded by the Indian Ocean and the Bay of Bengal.

The Ghauts enclose the main body of the Peninsula, which consists of table-lands and mountains and hills, elevated from 2,000 to 4,000 feet above the sea. The ranges of the Ghauts join on the north side of the great pass or *gap* of Coimbetoor, first made known during the military excursion of Colonel Fullerton. This striking pass is about sixteen miles wide. It is well known that ships navigating the Malabar coast during the north-east monsoon commonly experience a stronger gale in the

* See Note A. Appendix.

neighbourhood of Paniani than elsewhere; and this opening in the Ghauts appears to be the cause of this effect. It is also said that the lower part of the Coimbetoor country partakes of the rainy or south-west monsoon of the Malabar coast, which may be referred to the same cause. We regret we have not been able to find any statements in regard to the height of this pass above the Coromandel and Malabar countries.

From the south side of the gap the Ghaut range continues onwards in a southerly direction to Cape Comorin, where it terminates. The land at its extremity is low and flat, covered with trees, and not visible from the deck more than four or five leagues; but about half a mile inland is the mountain of Komari, the termination of the Ghauts, rising to a height of nearly 4,000 feet. From this mountain the southern extremity of India takes its name; its position is lat. 8° 4′ north, long. 77° 45′ east. Daniel says it is quite smooth and verdant to the very summit. Near the base bursts forth a magnificent cataract.

*Country below the Ghauts.*—On both sides of the Peninsula, interposed between the mountains and the coast, there is a tract named Payneenghaut, or below the Ghauts; that above these ranges have been named Balaghaut, or above the Ghauts. The country below the Ghauts, is composed of hilly and low flat country, varying in breadth from a few miles to eighty or ninety.

*Height of the Land in the Peninsula.*—The following determinations of heights we owe to Captain Cullen, of the Madras Artillery:*—

Without taking into account those habitable but confined tracts in the Nhilgerry hills, which are from 5000 to 7000 feet, and those on the Shervaroy or Salem hills, from 4000 to 5000 feet above the level of the sea, the table-land of Mysore presents the most elevated surface

* In Mr. Babington's paper in the 5th volume of the Geological Society's Transactions, the height of one peak, Bonasson hill, is said to be 7000 feet above the sea; and in a description of the Nhilgerry region by Dr. Smith Young, the peak of Dodapet, situated between 11° and 12° north lat. and 76° east long., is said to rise to an elevation of 8700 feet. It is much to be regretted that we have so few published reports of heights by actual geometrical or barometrical measurements, of the principal summits in the Peninsula.

of the Peninsula. The highest part of this table-land includes the stations of Bangalore, Nundidroog, Colar, and Oossoor, forming an area of sixty miles by fifty, and presenting a mean altitude of about 3000 feet. There is a rapid fall thence on every side; and the mean height of this belt may be stated at about 2400 feet. The valley of Seringapatam, including the town of Mysore, is also about the same height.

Trichinopoly, the capital of the southern division, is only about 250 feet above the sea; but the ground rises to the southward, attaining at one point the height of 800 feet; so that, if a line be drawn by Madura and Palamcotta to Cape Comorin, it would give a mean altitude of between 400 and 500 feet. The country in this quarter has a gradual rise from the eastern shore to the westward, where it is bounded by the great Travancore chain of mountains.

There is indeed a very remarkable ascent observable throughout almost the whole of the Peninsula south of Berar, from the eastern shore to the great Western Ghauts; and one need only cast his eye on the map to perceive this by the course of the rivers, which uniformly take an easterly direction, and fall into the Bay of Bengal. The country, from Madras by Arcot towards the bottom of the Pedanaigdroog pass, rises gradually to between 800 and 900 feet above the sea; and a similar slope may be considered to obtain for sixty or seventy miles southward of Madras, and for 130 or 140 miles north of it. The western coast is however more hilly, and is covered with jungles or forests, from the sea to the Western Ghauts. The mean height of the provinces of Malabar and Canara may be estimated at about 200 feet above the sea.

The Ceded Districts adjoining the Mysore territories on the north partake of the general slope which has been noticed. Bellary the capital, lying nearly in the centre of the province, is about 1600 feet above the sea, and the rise continues westward till it attains the elevation of 2500 feet. Belgaum in the Doab, situated at this height, is nearly the highest part of that province.

The average height of the province of Hydrabad, including an area of nearly the same magnitude as the Mysore table-land, is about 1900 feet above the sea; the city of Hydrabad lies low, near the northern edge of this area. The slope to the east and the north-west from this elevated tract is rapid; that to the north is much more gradual; the space to the south, between it and the Ceded Districts, comprehending the bed of the Kistna, is from 1100 to 1300 feet above the sea.

The elevation of Bangalore and Hydrabad thus interrupts the general slope of the Peninsula. The country round Jaulna is from 1600 to 1800 feet above the sea, and the general ascent from east to west is here very distinctly marked. Poonah, situated very near the Western Ghauts, is believed to be 2500 feet, or nearly so, above the sea.

The flat open plains of Nagpore seem to indicate their approach to the alluvial districts of the Ganges; for at the very base of the Peninsula, and at a distance of 400 miles from either the eastern or western sea, they attain only an elevation of 800 or 900 feet. Hinginghaut, fifty miles south of Nagpore, is only 700 feet above the sea.

The northern division, including Guntoor, is a series of level plains, elevated nowhere more than 50 feet above the sea. The Ghauts approach the coast near Vizagapatam, without causing any material alteration in the level of the intermediate valleys.

The following table contains some barometric measurements by Mr. Babington across the Peninsula from Madras to Tellicherry:—

| | Feet. |
|---|---|
| Arcot above Madras,........................ | 624[illegible] |
| Chittore above Arcot,........................ | 432[illegible] |
| Mooglee above Chittore,.................... | 578[illegible] |
| Pullamaurey above Mooglee,.................. | 579 |
| Nungily above Pullamaurey,.................. | 116 |
| Moolwagul above Nungily,.................. | 437[illegible] |
| Colar above Moolwagul,..................... | 3[illegible] |
| Mysore above Seringapatam,................. | 283 |
| Top of Ghaut above Peria,.................. | 251 |
| Midway Hut below top of Ghaut,............. | 973[illegible] |
| Bottom of Ghaut below Midway Hut,.......... | 1320[illegible] |

| | Feet |
|---|---|
| Mr Dyer's house, Tellicherry, below bottom of Ghaut,................................ | $329\frac{1}{3}$ |
| The sea below Mr Dyer's house, .............. | 119 |
| Malabar Sea, below Bangalore,.............. | 2698 |
| ———— Differs from Lambton's measurement, | 210 |

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## METEOROLOGY.

The atmosphere of India is chiefly tropical, a small extent only being situated in the southern part of the northern temperate zone. In some districts, however, the atmosphere, owing to the form, elevation, and nature of the surface of the land, exhibits characters almost identical with those of the northern temperate, and even of the polar regions. To place in full array before our readers a complete view of a subject so vast and complicated as the meteorology of India, would very far exceed the limits of the present work. We must therefore rest satisfied with the following details and views, which will illustrate, in a popular view, the meteorology of Indostan:—

1. *Changes in the Pressure of the Atmosphere.*—The changes in the pressure of the atmosphere, as ascertained by means of the barometer, have not in India been traced out with that care and accuracy which the importance of the subject demands. Of the barometric phenomena, the most curious are those that point out the daily atmospheric tides, the horary motions, or the double rise and fall of the barometer within twenty-four hours.* In India, as in the temperate and arctic regions, there are daily or hourly variations, in which the mercury in the barometer is always higher at 9 A. M. and 9 P. M., than at 3 P. M. and 3 A. M. These motions are much more distinct in India, and in tropical regions in general, than in temperate regions. From the observations of Humboldt we learn, that in tropical America these atmospheric tides are independent of changes in the weather and seasons. Thus, if the mercury is falling from nine in the morning until three or four in the afternoon, or if it be

* See Note B. Appendix.

rising from four in the afternoon until nine or eleven at night, a storm, an earthquake, or violent tempest of wind, does not affect or alter its course. It appears to be affected only by true time, or the position of the sun. In the tropical regions, he adds, the moment when the mercury begins to fall is so marked, that the barometer indicates true time within a quarter of an hour. Whatever truth may be in the latter observation of Humboldt, there can be no doubt as to the motions themselves. The only observations made in India with which we are acquainted, are the very interesting ones of Dr. Russel at Burhanpoor, in 24° north lat., and of Mr. Prinsep at Benares, in 25½° north lat., continued for three years, and which harmonize in general with those made in other tropical countries. At present we are not in possession of a range of observations sufficiently extensive to enable us to explain these horary motions. The speculations of Humboldt, Leslie, and others on this subject, are unsatisfactory. It is indeed evident, that these motions are connected not only with the atmospheric temperature, but also with its associated moisture. Until, however, we have a series of hourly-connected observations of the barometer and hygrometer we cannot attempt any explanation likely to be plausible.

The connexion of the mean monthly heights of the barometer with the south-east monsoons is also a subject of considerable interest, and is well illustrated in barometrical observations made at Seringapatam, Bangalore, Calcutta, Benares, Catmandoo, and Madras, for the particulars of which we refer to the original tables and observations of the observers.*

2. *Composition of the Atmosphere.*—It would appear from experiments made in different counties and at different heights, that the porportions of oxygen and azote, the principal constituents of the atmosphere, do not vary. Carbonic acid, another but minute constituent of the earth's atmosphere, is said to vary in quantity; for at one and the same place the carbonic acid

* See Asiatic Journal, three last vols.

suffers continued changes as to quantity, according to the temperature, wind, rain, and atmospherical pressure. Thus, near Geneva, according to Saussure, the mean quantity of this gas in 1000 parts by volume of air is at mid-day 5., or more accurately 4 9; the maximum is 6.2; minimum, 3.7. The same excellent observer finds, that in Switzerland carbonic acid *increases* in *summer*, but *diminishes* in *autumn*; further, that the quantity of carbonic acid at *mid-day*, in December, January, and February, is to that in June, July, and August, as 77 to 100. He also found, that over a *wet soil* the atmosphere contains less carbonic acid than over a *dry* one; that more exists in the atmosphere during the night than during the day; that the *superior* strata of the atmosphere contain more than the *inferior*; and, lastly, that a *violent wind* generally augments the quantity in the lower atmospheric strata during the day, by the intermixture of the lower and upper aërial strata, and sometimes by the wind blowing from a dry quarter. Besides azote, oxygen, carbonic acid, and water, the atmosphere occasionally contains, probably in some measure as *accidental* mixed parts, a particular vegeto-animal matter, and salts of various descriptions. The preceding details show what is expected from those who may undertake to make us acquainted with the chemical nature of the atmosphere of India,—a subject of great importance, but hitherto neglected.

3. *Effects of highly-attenuated Mountain Air.*—It is well known that on ascending high mountains, owing to the diminished pressure of the atmosphere, the animal, and indeed also the vegetable, functions are more or less affected. Some individuals of the human species feel these changes very intensely, while others experience comparatively little inconvenience. This latter circumstance has led some philosophers to imagine, that these enervating effects are solely owing to fatigue, and not to the attenuated state of the air,—an opinion, however, which is disproved by a fact stated by Gay Lussac, who, during his ærostatic voyage, while calmly seated in his balloon, experienced all those distressing symptoms

mentioned as occurring to travellers on their ascent of Alpine lands. Our enterprising countrymen, while exploring the Himmalehs, suffered from this case. Thus Captain Gerrard, in the account of one of his journeys, says, "Our elevation was now upwards of 15,000 feet, although we had but ascended in company with the river against its current. Here only began our toils, and we scaled the slope of the mountain slowly; *respiration was laborious, and we felt exhausted at every step.* The crest of the pass was not visible, and we saw no limit to our exertions. The road inclined at an angle of 30°, and passed under vast ledges of limestone. The projections frowned above us in new and horrid forms, and our situation was different from any thing we had yet experienced. *Long before we got up, we were troubled with severe headachs, and our respiration became so hurried and oppressive, that we were compelled to sit down every few yards, and even then we could scarcely inhale a sufficient supply of air. The least motion was accompanied with extreme debility and a depression of spirits; and thus we laboured for two miles.*"* Even the lower animals are observed to experience similiar inconvenience from attenuated air. Thus the yak and the horse are mentioned by Moorcroft and others, as suffering considerably when driven into high mountainous situations.

The effects of the attenuated air on sound is also a curious subject for observation and experiment. Saussure found sounds very feeble on the summit of Mount Blanc; Dr Schultes experienced the same on the Glockner and Stiria; and other travellers notice the comparatively small extent to which the voice can be heard at an altitude of 13,000 feet on Mount Rosa. Observations have never, as far as we know, been made on this point among the Himmalehs, although such would prove interesting. They might be made by the explosions of a small detonating pistol loaded with a constant charge, and the distances should be measured; for the voice looses much of its force from the diminution of muscular energy

* For other details on this subject, see that valuable periodical the Asiatic Journal.

in rarefied air, and distances are much underrated by estimation in such situations.

4. *Temperature of the Atmosphere.*—The problem of the distribution of the heat over the globe is a very complicated one, the solution of which requires a vast series of data, founded on observations continued for a long period of years by experienced meteorologists, provided with a full complement of the best instruments. In this investigation independent of other inquiries, we have to determine with accuracy the inflection of certain lines of equal annual temperature, the *isothermal lines;* also those of equal summer temperature, the *isothermal lines;* and of equal winter temperature, the *isochemenal lines;* we have to fix the relative positions of these lines in regard to each other, and to the meridians and parallels of latitude.* Such inquiries, although most interesting to the professed meteorologist, cannot be indulged in a work of this description with any prospect of advantage; and besides, the known data are by no means so satisfactory as to allow us to enter on the subject with that confidence which would be inspired by the conviction of our having to work with numerous good observations made with accurate instruments. Such being the case, we shall here simply notice the general range of Indian temperature, referring for the temperature of particular provinces to the observations under the head of each.

The range of temperature is very great, extending from the freezing-point of water, and even below it, to 130° of Fahrenheit's scale. The highest temperatures are met with in the great Western Desert and other sandy districts at the level of the sea, or nearly so, as the Circars and the Lower Carnatic. Elphinstone observed the thermometer at 112° in the Western Desert; but he remarks that, even where these high temperatures prevail, the evening air is cool to such a degree that the English gentlemen of the embassy used to suffer from cold during the night-marches, and were happy to kindle a large fire as soon as they reached their ground; yet the sun

* It is even of importance, in reference to climate, to determine by means of springs the *isogeothermal* lines.

became so powerful, early in the morning, that they always woke with a feverish heat which lasted till sunset. Humaioon, the father of the great emperor Akbar, lost most of his followers in the march over this dreadful desert; beneath a vertical sun, on burning sands and without water, tortured with violent thirst, they were seized with frenzies, burst out into piercing screams and lamentations; they rolled themselves in agonies on the parched soil, their tongues hung out of their mouths, and they expired in most exquisite tortures.* Speaking of the Circars, Heyne says, nothing can be more distressing than the failure of the sea-breeze for several successive days, when the land-wind blows all night, and heats every thing so much as to become distressing to the touch. This was the case in the year 1799, in the Northern Circars, for about a fortnight. The thermometer at *midnight* stood at 108° F., and at eight o'clock A. M. at 112°. Neither wood nor glass is capable of bearing the heat for any length of time; the latter, as shades, globe-lanterns, &c., crack and fly in pieces; the former warps and shrinks, and the nails fall out of the doors and tables. Heyne never saw the thermometer higher than 115° F. in the coolest part of the house. Some persons affirm, that in such cases they have seen it as high as 130° F. The climate in the lower part of the Carnatic is one of the hottest in India. Frost never occurs in the Deccan, or to the south of it; but sometimes the temperature of Hydrabad is only 6° or 8° above freezing. In Malwah, during the hot season, the parching winds from the northward and westward, that prevail in most parts of India to an intense degree, are comparatively mild and of short duration. The thermometer, however, during the day rises sometimes as high as 98°; but the nights are invariably cool and refreshing. During the cold season the thermometer sinks as low as 28°. In the higher parts of India, as at Delhi, in north lat. 28° 37′, for example, the winter's cold is sometimes 3° or 4° below the freezing-point of water, and the tanks are frozen entirely over. In a Persian

* Dow's Ferishta, 8vo edition, II. 150.

work called Mutaghevin, or Modern Times, there is mention made of a frost at Delhi which continued three nights, in consequence of which brazen vessels filled with water burst.

5. *Making of Ice in India.**—Ice is considered a great luxury, and hence is made in many parts of the country. All over Upper India it is procured in a very simple manner. A number of broad shallow earthen pans are placed on a layer of dry straw, and filled with water. In the night even the slight frost felt is sufficient to cover these with a thin crust of ice, which is carefully collected and packed up. An intelligent gentleman, David Scott, Esq., says, the subject of artificial congelation is not so well understood by scientific men in Europe as it might be. The old story of *evaporation* being at the bottom of the process, and *porous* pans being necessary for its success, is repeated by one author after another, although nothing can be more erroneous. In respect to the first, it seems sufficient to observe that, when ice produced in temperatures above the freezing-point, a plentiful deposition of dew is always going on, which seems to be altogether inconsistent with the idea of air being in a state capable of receiving fresh accessions of moisture. Mr. Scott found by repeated experiments, that ice may be produced although a thin film of oil be spread over the surface of the water,—the latter being contained in *glazed* plates, which indeed answer much better than the *porous* pans of the country, the ice in them being invariably thicker, and the water, when it does not actually freeze, somewhat colder than the similar contents of porous pans placed in exactly the same situation. The fact is, that the natives use *porous* pans from necessity, there being no other description of earthen-ware manufactured in the country; but so well are they aware that the *porosity* of the vessels is of no advantage, that they usually rub them with grease for the purpose of more easily taking out the ice, and also

* Ice is now regularly imported from America, and it is probable, we may have a supply from the northern parts of India.

facilitating the process, by keeping the straw upon which they are placed in a perfectly dry and non-conducting state. Mr. Scott repeated some of Dr. Well's experiments, and obtained interesting results. On one occasion, a turban being suspended across the pit three feet above the pans, it, as it always does, prevented the formation of ice in those immediately under it; and in several which it only partially covered, ice was formed on the half of the water out of this perpendicular line, while that under the turban was fluid. Two strings crossing each other, and placed at a less height above a pan, will also divide the ice into four quarters; but it is obvious that these results will not always be obtained; for, if the temperature be rather lower than would be necessary to freeze the water, supposing no impediment to exist, the whole may be frozen, although partially covered; and, on the other hand, if just sufficient to freeze the water under the most favourable circumstances, the contents of a vessel not fully exposed to the influence of the sky may remain fluid throughout. Mr. Scott could never make ice (operating, however, on a small scale) when the temperature exceeded 41° F. on the level of the pits; but on such occasions the temperature is much higher at some distance from the ground, and a series of bottles filled with water, suspended from a mast of about seventy feet high, exhibited an increase of 1° for every ten feet of elevation. Mr. Scott adds, that, therefore, Sir H. Davy is right in saying ice may be made when the thermometer is above 50°, if he allude to the upper regions of the air, or hills of moderate height; but, as has been already said, it cannot be made when the thermometer, suspended at three feet from the ground on the plain, stands at about 41°. Mr. Scott's experiments extend to the height of 3400 feet, at which elevation, on a *detached* mountain, the temperature of the air at sunrise is several degrees *higher* than in the Plain of Bengal.

6. *Snow-line.*—Although, as already remarked, the thermometer sometimes stands as low as 28° F. in Malwah, yet, as far as we know, snow has not been observed in India to the south of the grand Himmaleh mountain-

barrier. On several ranges of this vast Alpine land snow lies all the year. The lower boundary of this snowy covering is named the *snow-line*, which varies in height according to the season of the year, being highest during summer and lowest during winter. Of late years the height of this line in different parts of the world has engaged the particular attention of meteorologists, and the investigation has led to interesting results. The subject has been pursued with energy among the Himmalehs by several active British officers,—of whom Webb, Gerrard, and Herbert, are the most distinguished. In November, 1817, Captain Webb published a memoir on the heights of the Himmalehs, in which, by tracing the Gauri river upwards, he found that it bursts from the snow at the elevation of 11,543 feet,—a striking coincidence between actual observation and the calculated formula of authors, which assigns 11,400 feet. Mr. Colebrooke, in a paper published in Brande's Journal from the observations of Captain Webb, for the first time remarked that the inferior limit of perpetual snow does not every where descend so low as theory would lead us to conclude.

According to theory, the height of the snow-line between latitudes 27° and 35°, about the range of latitude of the Himmalehs, is as follows:—

| Latitude. | Height of the Snow line. Feet. |
|---|---|
| 27° | 12,145 |
| 28° | 11,930 |
| 29° | 11,710 |
| 30° | 11,484 |
| 31° | 11,253 |
| 32° | 11,018 |
| 33° | 10,778 |
| 34° | 10,534 |
| 35° | 10,287 |

The following facts show not only the difference between the line of theory and of actual observation, but also that the snow-line is higher on the northern than the southern side of the Himmalehs:—

7. *General great Height of the Snow-line on the Himmalehs.*—The village and temple of Milem were found

by Captain Webb at the respective elevations of 11,405 and 11,682 feet above Calcutta; extensive fields of buck-wheat and Tartaric barley occupying the space between the two. A year after these observations were made, viz. on the 21st June, 1818, Captain Webb proceeded southward from Joshi-mat-h, and from the Dauli river observed barometrically the altitude of a station on the ridge of mountains to the south. He found it to be 11,680 feet above the level of Calcutta; yet the place was surrounded by flourishing woods of oak, long-leaved pine, and arborescent rhododendrons, and the whole surface covered with a rich vegetation as high as the knee, extensive beds of strawberries in full flower, and plenty of current-bushes in blossom all around, in clear spots of rich black mould. On the following day, Captain Webb reached the summit of the pass Pilgointi Churhai, and found its elevation to be 12,642 feet above the same level, or more than 12,700 feet above the sea. A dense fog confined the prospect; but no snow was to be seen contiguous to the spot. The surface exhibited a black soil, unless where the bare rock appeared, covered with strawberry plants, buttercups, dandelions, and a profusion of other flowers. The goat-herds of the country are accustomed to lead their flocks to pasture during July and August upon a yet loftier ridge, estimated to be as much above the pass of Pilgointi as this was above the preceding day's encampment,—that is, nearly 1000 feet; and which therefore removes the snow-line to a still higher elevation.

The temple of Kedar-nath, according to a mean of five barometrical measurements, is 11,897 feet above Calcutta, or 12,000 feet above the level of the sea; but no snow remained in the vicinity of the temple later than the beginning of July; so that under the latitude of 30° 40′, at the last-mentioned elevation, the snows were not perpetual on the *southern side* of the Himmaleh mountains.

Captain Webb's observations on the summit of the Nitee Ghaut afford another example of this interesting fact. At the elevation of 16,814 feet, not a vestige of snow was to be seen on the Ghaut, nor upon the pro-

jecting shoulder of the mountain-ridge, rising about 300 feet on the western side of the pass; and we may hence conclude that the height of the snow-line on the *northern side* of the Himmaleh range cannot be less than 17,000 feet. The great elevation of the table-land of Tartary is, from its connexion with the distribution of the snowy boundary in these regions, deserving of particular notice. By observations made on the ridge of the Nitee pass, Captain Webb found the Sutledge to flow in a plain 14,924 feet above the sea; yet so far are the *undes*, or great plains, from being buried in eternal snow, as our common estimates would lead us to suppose, that the banks of the river afford the finest pasture for thousands of quadrupeds throughout the year. The town of Daba appears to be inhabited all the year, and not a temporary residence. In the neighbourhood of this place, and near Doompoo, both considerably higher than the bed of the Sutledge, Captain Webb was informed that the finest crops of the grain called *ora* were gathered, from which the natives make their bread.

Captain Gerrard, when proceeding by the Chárang pass, 17,348 feet high, to the valley of Nangalti, says many beds of snow were crossed, and that at the height of about 16,300 feet the "*continuous snow-beds commenced.*" In another place, however, he remarks, that the mountains in the neighbourhood of Chárang are all of blue slate, naked to their tops, and exhibiting decay and barrenness in their most frightful forms. They tower in sharp detached groups to about 18,000 feet, no vegetation approaching their bases, nor do their summits offer any rest to snow. Upon the left bank of the Tagla, mountains 16,000 feet high appear, on which no snow was observed. The summits on the right bank seem to be 18,000 feet, and with but little snow in streaks. The mountains also which enclose the dell of the Tagla are between 19,000 and 20,000 feet high, and just tipped with snow.

The difference of height of the perpetual snows on the northern and southern sides of the Himmaleh mountains is farther shown by the following remarks of Captain

Gerrard. Zamsiri, a halting-place for travellers on the banks of the Shelti, is 15,600 feet above the sea,—a height equal to that of the passes through the outer range of the Snowy Mountains; and yet, he says, there is nothing to remind the traveller of the Himmalehs. Gently sloping hills and tranquill rivulets, with banks of turf and pebbly beds, flocks of pigeons and herds of deer, present the idea of a much lower elevation. But Nature has adapted the vegetation to the country; for did it extend no higher than on the southern face of the Himmalehs, Tartary would be uninhabitable either by man or beast. On ascending the *southern* acclivity of the snowy range, the extreme height of cultivation is found 10,000 feet; and even there the crops are frequently cut green. The highest habitation is 9500 feet; 11,800 feet may be reckoned the upper limit of forests, and 12,000 that of bushes, although, in a few sheltered situations, dwarf-birches and small bushes are found almost at 13,000 feet. But if we go to the Baspâ river, the highest village will be found at an elevation of 11,400 feet, cultivation reaching to the same altitude, and forests extending to 13,000 feet at least. Advancing farther, we find villages at the last-mentioned elevation, cultivation 600 feet higher, fine birches at 14,000 feet, and *tama* bushes, which furnish excellent firewood, at 17,000 feet. Eastward, towards Manasawara, according to the accounts of the Tartars, crops and bushes thrive at a still greater height.

These facts, then, show not only that the snow-line generally is higher than was anticipated, but also that we must ascend several thousand feet more on the northern than the southern acclivity of this Alpine land before we reach the perpetual snow. Many explanations have been given of this striking fact which we cannot discuss here. It is sufficient to remark, that the radiation from the surface of the table-land of Thibet, the dryness of the air throughout Central and Northern Asia, the small quantity of snow which falls during winter when the temperature sinks to 10° 4′ F. or + 5° F.; lastly, the serenity and transparency of the atmosphere which reigns along

the northern declivity of the Himmalehs, and which augments, at the same time, the irradiation of the table-land, and the transmission of the radiant heat which the table-land emits, may be considered as the principal causes of the great difference of the height of the snow-line on the north and south sides of the central mountain-ranges of India.

8. *Evaporation.*—Evaporation is that process by which the atmosphere is furnished with the moisture it contains. Water assumes the vaporic form at all temperatures, however low. Thus vapour rises not only from the plains of Bengal, but also from the icy and snowy mantles on the highest ridges and summits of the Himmalehs. Hitherto, owing to the want of observations, naturalists have not been able to trace out, in a satisfactory manner, the phenomena of evaporation in different climates; although we know, from its general relations to heat, that it is most powerful in the equatorial regions of the globe, and gradually diminishes towards the poles. The instruments necessary for ascertaining the power of evaporation have never, as far as we know, been used in India; but the time is not distant, we hope, when these will find a place in Indian meteorological observatories.

9. *Humidity of the Atmosphere.*—The earth, as is well known, is surrounded by an atmosphere of air and aqueous vapour. These two matters are mechanically mixed, and each is governed by its own peculiar laws. In order to supply the atmosphere with aqueous vapour, the process of evaporation is almost in constant activity; and Nature has set limits beyond which this vapour cannot pass, so as to prevent excessive moisture and long-continued dryness. This dependence of moisture on temperature enables us to trace some of the phenomena of its distribution. There is, as is well known, a gradation of heat from the equator to the poles, and also from the surface of the earth upwards into the higher regions of the air. Generally speaking, the lowest stratum of the atmosphere, in whatever latitude it is found, must contain the greatest quaintity of aqueous vapour, on account of its being nearest the source whence that

moisture is supplied. If an equality of temperature existed, therefore, at the surface, the same quantity of air, in whatever latitude it was taken, would contain, when completely saturated, the same quantity of moisture. But since the temperature diminishes with the latitude, a given volume of air, in a perfect state of saturation, must contain less and less moisture as we approach the poles. From a similar cause the moisture of the atmosphere must diminish as we ascend above the earth. Local circumstances also affect the moisture of the atmosphere: thus over coasts it is much moister than in the interior of continents, as is well exemplified in the moist atmosphere of Western Europe, when contrasted with the very dry atmosphere of Asia. The atmosphere over wooded districts is moister than over those sparingly covered with vegetation; and the driest reposes upon arid sandy tropical plains. In India, for the most part, between December and June, while the general motion of the air is southward to the sea, the atmosphere is comparatively dry. It attains its maximum of humidity during the blowing of the south-west monsoon. After the rains cease, *fogs* in the mornings continue for some time, and re-appear before the commencement of the rainy season. Such fogs are useful, Heyne remarks, to the growth of plants, as they clear them from dust, open their pores, and supply them with nourishment, which they could not obtain from the earth in this season. Without these irrigations very little saltpetre could be made, as the earth which contains it can be recognised only after it has attracted this moisture.

The only accurate mode of ascertaining the quantity of moisture in the air is by means of the *hygrometer*, an instrument which has hitherto been but sparingly used in India. We regret this, as the extensive employment of this instrument would throw much light on the climate of our eastern empire. Hygrometers ought, along with other meteorological instruments, to be distributed by government throughout India.

10. *Dew.*—Dews, in many parts of India, are heaviest in December and January, before the fogs set in. They

become perceptible before eight or nine in the evening, when the atmosphere is perfectly serene. On the Coromandel coast, according to Heyne, the inhabitants are not so much afraid of exposure to them as those of other countries. During the foggy season, the *vinegar of Sennagalu* (the *acid dew* of some authors), so much prized by the Moormen and rich Hindoos, is obtained. It is made by spreading pieces of muslin cloth on the flowering sennaga (*circer arietinum*, Bengal *gram*) after sunset, and removing them before the sun gets through the clouds of mist. The moisture with which they are saturated is wrung out, and preserved for use. The acid juice is said to contain oxalic, malic, and a little acetic acid.*

11. *Rain.*—The humidity communicated to the air by evaporation is returned to the earth chiefly in the form of rain. The quantity of rain which falls is greatest at the equator, gradually decreasing towards the poles. The quantity is estimated by means of the rain-gauge, and is given in inches and fractions of inches. When we say, for example, that one inch has fallen in a district in a specific time, it means that, if all the rain which fell in that time had remained on the surface, it would have covered it to the depth of one inch. This explanation is offered, as some of our readers might not be aware without it of the precise meaning of the following details.

In India the rains occur at determinate periods, named the *rainy seasons.* In general there is but one rainy season, during June, July, August, September, and October, during the south-west monsoon; little or no rain falling during the other months. In the Peninsula, however, there are in some places *two rainy seasons,*—one during the south-west monsoon on the west side, the other in the time of the north-east monsoon on the east side of the country.

Rain falls not only all over the Peninsula and middle India, but also among the Himmalehs, and at a great

* Dew collected from the leaves of plants contains a large dose of carbonic acid; thus Lampadius found 2 per cent. of carbonic acid in dew collected from the leaves of the *alchemilla vulgaris.*

height above the sea. Thus Gerrard, in a snow-covered region 15,000 feet high, experienced a shower which lasted for two hours. He was also detained three days by incessant rain at Shalpia, a resting-place for travellers.

On the coast of Malabar, mean latitude about 11½° north, the annual amount of rain is stated at 123½; at Bombay, the fall observed during twelve years is stated at 82 inches annually; at Calcutta 81 inches during the year. Of the quantities falling during *successive months* the results are necessarily very variable. The means of twelve years' observations for Bombay afford the following results:—

| | |
|---|---|
| June, | 24.00 inches |
| July, | 23.95 |
| August, | 18.87 |
| September, | 14.06 |
| October, | 1.06 |

the greatest fall being found in June and July, and declining to a very small amount in October.

The quantity of rain which sometimes falls in a short time is very great. Thus, "a letter from Mr. Scott says, there fell at Bombay during the first twelve days of the rainy season thirty-two inches of rain, so that all the roads became like rivers. In England the average fall for the whole year is thirty-two inches,—the same as fell at Bombay in the course of twelve days. Between Bombay and the southern part of the Malabar coast, places not 500 miles distant from each other, very great differences prevail, both in individual years and in the amounts of the annual means. The following are a few of the results of each:—

| Years. | Amount of Rain at Bombay in inches. | Amount of Rain on the Coast of Malabar in inches. |
|---|---|---|
| 1817 | 103.79 | 136.70 |
| 1818 | 81.14 | 169.19 |
| 1819 | 77.10 | 135.47 |
| 1820 | 77.34 | 147.18 |
| 1821 | 82.99 | 98.44 |
| 1822 | 112.21 | 145.60 |
| 1823 | 61.70 | 121.67 |
| Means. | 85.18 | 136.32 |

Here the average annual amount of rain differs sixty per cent. within so small a geographical limit.

From the want of observations we have no opportunity of laying before our readers any details in regard to the relative proportions in the mountainous, hilly, flat, low, and littoral parts of India, nor have met with any very accurate registers of the daily and nightly fall.

12. *Monsoons.*—India, though it approaches nearer to the equator is not so hot as the Sandy Arabia or the adjacent countries. The course of the seasons is also more regular and constant, and it is in this part of the world that we meet with those remarkable winds,—the seasonal or periodical winds called *monsoons,*—which throughout India blow nearly one-half the year from south-west to north-east, and the other half from north-east to south-west, and are the great distributors of its rain and modifiers of its climate. The most remarkable rainy season is that called the south-west monsoon. It extends from Africa to the Peninsula of Malacca, and deluges all the countries within certain lines of latitude for about four months of the year. In the southern parts of India this monsoon commences about the beginning of June, but it gets later as we advance towards the north. Its approach, says Mr. Elphinstone, is generally announced by vast masses of clouds that rise from the Indian Ocean and advance towards the north-east, gathering and thickening as they come near the land. After some threatening days the sky assumes a troubled appearance in the evenings, and the monsoon in general sets in during the night. It is attended by thunder-storms far exceeding in intensity those of temperate regions. It generally begins with violent blasts of wind, which are succeeded by floods of rain. For some hours lightning is seen almost without intermisson; sometimes it only illuminates the sky, and shows the clouds near the horizon; at others it discovers the distant hills, and again leaves all in darkness, when in an instant it re-appears in vivid and successive flashes, and exhibits the nearest objects in all the brightness of day. During all this time thunder never ceases to roll, and is only silenced by some

nearer peal, which bursts on the ear with such a sudden and tremendous crash, as can scarcely fail to strike the most insensible heart with awe.* At length the thunder ceases, and nothing is heard but the continued pouring of the rain and the rushing of the rising streams. The next day presents a gloomy spectacle; the rain still descends in torrents, and scarcely allows a view of the blackened fields; the rivers are swollen and discoloured, and sweep down along with them the hedges, the huts and the remains of the cultivation which was carried on during the dry season in their beds.

This lasts for several days; after which the sky clears, and discovers the face of nature changed as if by enchantment. Before the storm the fields were parched up, and except in the beds of the rivers scarcely a blade of vegetation was to be seen; the clearness of the sky was not interrupted by a single cloud, but the atmosphere was loaded with dust, which was sufficient to render distant objects dim, as in mist, and to make the sun appear dull and discoloured, till he attained a considerable elevation; a parching wind blew like a blast from a furnace, and heated wood, iron, and every other solid material, even in the shade; and immediately before the monsoon this wind had been succeeded by the still more sultry calms. But when the first violence of the storm is over, the whole earth is covered with a sudden and luxuriant verdure; the rivers are full and tranquil; the air is pure and delicious; and the sky is varied and embellished with clouds. The effect of the change is visible on all the animal creation, and can only be imagined in Europe by supposing the depth of a dreary winter to start at once into all the freshness and brilliancy of spring. From this time the rain falls at intervals for about a month, when it comes on again with great violence, and in July the rains are at

* To persons, Mr. Elphinstone says, who have long resided in India, these storms lose much of their grandeur; yet they sometimes rise to such a pitch as to make an impression on those most habituated to them. He was told by a gentleman who had been for some time in Malabar, the province most distinguished for the violence of the monsoon, that he there heard a clap of thunder which produced a silence of a minute in a large party of officers, and made a great part of the company turn pale.

their height; during the third month they rather diminish, but are still heavy; and in September they gradually abate, and are often entirely suspended, till near the end of the month, when they depart amidst thunders and tempests as they came.

Such is the monsoon in the greater part of India. It is not, however, without some diversity, the principal feature of which is the delay in its commencement, and the diminution of the quantity of rain as it recedes from the sea. It is naturally most severe near the sea, from which it draws its supplies, and is exhausted after it has passed over a great tract of land. For this reason the rains are more or less plentiful in different districts according to their distance from the sea, except in those near high mountains, which arrest the clouds, and procure a larger supply of rain for the neighbouring tracts than would have fallen to their share if the passage of of the clouds had been unobstructed.

The obstacle presented to the clouds and winds by the mountains has another effect of considerable importance. The south-west monsoon blows over the ocean in its natural direction; and, though it may experience some diversities after it reaches the land, its general course over India may still be said to be towards the north-east, till it is exhausted on the western and central parts of the Peninsula. The provinces in the north-east receive it in a different manner: the wind which brings the rains to that part of the continent originally blows from the south-west over the Bay of Bengal, till the mountains of Himmaleh, and those which join them from the south, stop its progress and compel it to follow their course towards the north-west. The prevailing wind, therefore, in the region south-west of the Himmalehs is from south-east; and it is from that quarter that our provinces in Bengal receive their rains. But when the wind has reached so far to the north-west as to meet with the Hindoo Coosh, it is again opposed by that chain of mountains, and turned off along its face towards the west, till it meets the projection of Hindoo Coosh and the range of Solimaun, which prevent its farther pro-

gress in that direction, or at least compel it to part with the clouds with which it was loaded. The effect of the mountains in stopping the clouds borne by this wind is different in different places. Near the sea, where the clouds are still in deep mass, part is discharged on the hills and the country beneath them, and part passes up to the north-west; but part is said to make its way over the first hills, and produce the rains in Thibet.

The above observations, Mr. Elphinstone continues, will explain, or at least connect the following facts:— The south-west monsoon commences on the Malabar coast in May, and is there very violent; it is later and more moderate in Mysore; and the Coromandel coast, covered by the mountainous countries on the west, is entirely exempt from it. Farther north the monsoon begins early in June, and loses a good deal of its violence, except in the places influenced by the neighbourhood of the mountains of the sea, where the fall of water is very considerable. About Delhi, it does not begin until near the end of June, and the fall of rain is greatly inferior to what is felt at Calcutta or Bombay. In the north of the Punjaub, near the hills, it exceeds that of Delhi; but in the south of the Punjaub, distant both from the sea and the hills, very little rain falls. The clouds pass with little obstruction over Lower Sinde, but rain more plentifully in Upper Sinde, where these rains, though not heavy, are the principal ones in the year.

By the beginning of October, when the south-west monsoon or rainy season is nearly at an end, the change gradually takes place from the south-west to the north-east monsoon. This monsoon is attended with dry weather throughout the Peninsula, excepting on its eastern side on the coast of Coromandel. On this coast the north-east monsoon brings the periodical rains, which begin about the middle of October, and end generally about the middle of December. From December to the beginning of March this monsoon continues, but is now a dry wind. The weather is at this season cool and agreeable. The north-east winds cease about the end of February or beginning of March, and from

this period to the beginning of June the winds are irregular and the heat great all over the Peninsula. The winds are chiefly from the south at this time in the Bay of Bengal and on its shores, and are hot, moist, and relaxing. About the end of May or beginning of June, as already remarked, the south-west monsoon begins, and is attended with the periodical rains in all parts of the Peninsula excepting the Coromandel coast, which then suffers greatly from heat and drought.

13. *Hail.*—In India hail falls only during the hottest seasons of the year, frequently in pieces the weight of half an ounce, and is accompanied by heavy thunder and storms or gusts of wind. In the Peninsula showers are more frequent in the country above the Ghauts than in that below them. The natives call the hail *rainstones*, and ascribe to it invigorating virtues. Although none of the mountains in Peninsula India reach the snow-line, and frozen water rarely appears there otherwise than in the form of hail, snow being unknown in Southern India, yet some writers maintain that hail-storms never occur in the torrid zone, while others affirm that they never appear there except at an elevation of not less than 1500 or 2000 feet above the sea. This statement, however, is far from being correct; for although hail-storms are not so common and destructive in India as in the south of Europe,—the grand region of these storms,—still they do frequently happen, even at the level of the sea. In May, 1823, a violent hail-storm occurred at Hydrabad, which is about 17° north latitude, at an elevation of not more than 1000 feet above the sea. The hailstones were of considerable size, and a sufficient quantity was collected by the servants of a military mess to cool the wine for several days. A hail-storm occurred at Darwar, north latitude 16° 28′, east longitude 75° 11′, in May or June, 1825. The height of Darwar above the sea is 2400 feet, but it is near no high range of mountains. The hailstones had a white porous nucleus, and varied from the size of a filbert to that of a pigeon's egg. A similar storm occurred at the same place, and about the same season, in 1826. These, Dr. T. Christie

says, were the only hail-storms that came under his notice during five years' residence in India; but from the testimony of others he mentions the following:—Lieutenant-Colonel Bowler of the Madras army informed him that he witnessed a violent hail-storm at Trichinopoly about the middle of the year 1805, when the hailstones were nearly as large as walnuts. Another very violent hail-storm occurred in the Goosma Valley, about twenty-five miles west of Ganjam, and only a few feet above the sea, when the same officer was in camp there about the end of April, 1817. It commenced about half-past three in the afternoon. The weather had previously been very sultry, with hot blasts of wind, aud heavy clouds, which appeared almost to touch the tops of the tents. On the hail falling, the air became on a sudden disagreeably cold, as it had been before oppressively hot. We are told by Heyne, in his Historical and Statistical Tracts on India, that "masses of hail of immense size are said to have fallen from the clouds at different periods" in the Mysore country; and that, "in the latter part of Tippoo Sultan's reign, it is on record, and well authenticated, that a piece of ice fell near Seringapatam of the size of an elephant." Of course, we are not to believe this to the letter,—we must make some allowance for oriental exaggeration. It is needless to multiply examples; for there is probably not an officer who has been many years in India who cannot bear testimony to the frequency of hail-storms in that country.

14. *Falling Stars, Fire-balls, and Meteoric Stones.*—Falling stars are of frequent occurrence, falling or rather shooting through the atmosphere in countless numbers and at all times of the day, in India as in Europe. Fire-balls also are not very uncommon. Colonel Blacker gives an account of a meteor, having the appearance of an elongated ball of fire, which he observed on the 3d November, 1826, a little after sunset, when on the road between the courthouse and the town-hall of Calcutta. Its colour was pale, for the daylight was still strong, and its larger diameter appeared greater and its smaller less than the semi-diameter of the moon. Its

direction was from east to west, its track nearly horizontal, and its altitude about 30°. As it did not apparently move with the velocity of ordinary fire-balls, it was probably at a great distance, and consequently of large size. So long as Colonel Blacker saw it, which was for five or six seconds, its motion was steady, its light equable, and its size and figure permanent. It latterly, however, left a train of sparks; soon after which it suddenly disappeared, without the attendant circumstance of any audible report. These fire-balls sometimes burst, and precipitate meteoric stones and iron. Lord Valentia and Mr. Howard mention stones that fell in this way from the atmosphere of Bengal on the 19th December, 1798; several fell near Moradabad in 1808, and nineteen were found at Futtypore, in the Doab, on the 5th November, 1814. Dr. Tytler says, that on the evening of that day, shortly after sunset, before daylight had entirely faded, a meteor was distinctly seen, shooting with considerable velocity in a direction nearly north-west. This appearance was also observed by the Europeans in the lines and natives in the city, and is described to have comprised a blaze of light, surrounding a red globe about the size of the *moon*, which impressed the spectators with the idea of that luminary descending from the skies. The same phenomenon, and at the same moment of time, was seen at Hazareebaug, in Bengal, a distance of upwards of 250 miles eastward from Allahabad. The meteor descended at Rourpoor, nearly seventy miles north-west from the station of Allahabad, immediately after it was seen at that place. Its fall was accompanied with noises resembling the explosion of distant artillery, and a stone was seen falling, which in the act of descending is said to have emitted sparks similar to those proceeding from a blacksmith's forge. A strong sulphureous smell was also perceptible, and when first discovered the stone was hot to the touch. Besides the stone thus actually known to have fallen, several others of a similar description were picked up, at the distance of several coss from each other, whence it appears that a shower of stones in this instance took place. The fragments amounted to several

pounds in weight. One weighed nearly one pound six ounces avoirdupois, and exactly resembled a body coated with black paint or pitch. Its interior was of an ash-gray colour, and contained embedded metallic-looking particles. Its specific gravity is stated as varying from 3, 35.2 to 4, 281. On the night of the 7th August, 1822, a meteoric stone fell near the village of Kadonah, in the district of Agra, with much noise as of cannon, the wind awakening those who were asleep, and alarming a watchman who heard it fall; on making search in the morning it was found warm, and with little smoke rising from it. The stone was shown in London in 1827. Several stones fell in the district of Azim Gerh on the 27th February, 1827.

These fire-balls, and the meteoric stones they drop, are considered as formed in the earth's atmosphere, and therefore as of tellurian atmospherical origin.

15. *Mirage.*—On viewing distant objects, it often happens, under certain circumstances, that these objects present many images which are straight, oblique, or inverted, and always more or less changed in the contour. It is the appearance of these images, without any visible reflector to produce them, which constitutes *mirage.** In explanation of this phenomenon it may be remarked, that as soon as the soil becomes heated the lower stratum of air is also effected by the calorific influence. Numerous aërial currents are established, and an undulatory motion taking place in the air, distant objects become changed in form, and variously distorted and broken. If when these changes are going on a calm should prevail, and the mass of atmosphere upon the plain remain at rest while the stratum in contact with the ground becomes gradually heated, mirage will arise. In such cases the observer will see distant objects in their natural positions and forms; but *below* them their images will be seen reversed, and the spectator believe that he is looking at a *reflection* from the surface of a body of water. The sky also joins in completing the illusion, its image being reflected in the same manner. The whole visible appearances, the French

* See Appendix C.

philosophers who visited Egypt remark, are indeed the same as those usually exhibited by water. All thelaws by which the observer has been accustomed to judge of the existence of water, viewed at a distance, are here called into action, and the man of science as well as the peasant alike find themselves deceived.

This curious appearance is noticed by several of our Indian travellers. Thus, Mr Elphinstone, in describing his passage through the Great Desert, says, "On the 25th November we marched twenty seven miles to two wells in the Desert. In the way we saw a most magnificent mirage, which looked like an extensive lake, or a very wide river. The water seemed clear and beautiful, and the figures of two gentlemen who rode along it were reflected as distinctly as in real water." The same very interesting writer remarks, "On the 22d we made a march of thirty miles to Moujgur; the heat of the afternoon was intense, while we halted as usual in the naked plain to give our people some water and to take some refreshments ourselves. In the course of the day several hundred skins of water came to us from Moujgur, where Bahawul Khan had sent his principal officers to receive us. Towards the evening many persons were astonished with the appearance of a *long lake, enclosing several little islands.* Notwithstanding the well-known nature of the country, many were positive that it was a lake, and one of the surveyors took the bearing of it."

Other varieties of mirage are noticed by Colonel Tod in his valuable work on Rajasthan.

16. *Black Colour of the Sky over the Himmalehs* —The sky, when viewed from lofty mountains, presents a deep blue colour approaching to black. This fact is often mentioned by travellers among the Himmalehs. Thus, near the sources of the Ganges, the dazzling brilliancy of the snow was rendered more striking by its contrast with the *dark-blue, approaching to blackness,* of the sky; and at night the stars shone with a lustre which they do not present in a denser atmosphere. "It was curious to see them," says Captain Hodgson, "when rising, appear like one sudden flash as they emerged from behind the

bright snowy summits close to us; and their disappearance, when setting behind the peaks, was as sudden as we generally observed it to be in their occultations by the moon." At Zinchin, 16,136 feet above the sea, the atmosphere exhibited that very *dark-black colour* which is observed from great elevations. The sun shone like an orb of fire without the least haze. At night, the part of the horizon where the moon was expected to rise could scarcely be distinguished before the limb touched it; and the stars and planets shone with a brilliancy never seen unless at great heights.

With a transit-telescope of thirty inches, and a power of thirty, stars of the fifth magnitude were distinct in broad day; but none of less size were perceptible. At Sùbáthù, 4200 feet above the sea, stars of the fourth magnitude require a power of forty to make them visible in the day.

17. *Sunrise and Pillar of Light, or Zodiacal Light, in India.*—Sunrise is often characterized by the appearance of a pillar of light, which never fails to make a strong impression on those who take an interest in the natural phenomena around them, and who, for the first time, witness this beautiful appearance. Dr Adam, in the following description of Indian sunrise, mentions this luminous appearance:—

"The country in the neighbourhood displays a thousand charms compared with the district near the Jumna. The roads are dry, and the rocky elevations in front, having a covering of beautiful shrubs, entwined with numerous varieties of climbing plants, give quite a new feeling to the mind on viewing the prospect. New animals, too, inhabitants of these, present themselves. The peacock, arrayed in all his gorgeous hues, and shining with a native glossiness of plumage, is not unfrequently seen perched on a projecting block of granite, while herds of antelopes bound along the plain below; and the shrill cry of the Indian partridge, heard on every hand, first cheers the traveller with the opening day. I was much delighted one morning here with viewing the natural phenomenon of sunrise. Contrary to my usual practice, I had started early with my baggage. It was

quite dark, excepting what light the stars afforded, which in India is always considerable at this season (October), when not a cloud obscures the expanded vault of the heavens. After moving on for some time, on turning my eye towards the east, I could perceive the first appearance of day. It was not dawn, but a mere grayish pillar of light shooting from the horizon upwards, in the shape of a comet's tail, but without lustre; the effulgence, if it could be so called, resembling that of the milky way more than any other object in nature which I have seen. The dull *pillar of light* was well defined. It continued a long time apparently little increased in size, and without having acquired much brilliancy. At length its sides near the bottom gave way, and the light, now stronger, diffused itself latterly to a considerable extent. By and by the stratum of clouds immediately over this expansion displayed the roseate hue of morn, and the whole heavens became (though yet faintly) illuminated. The rosy tints, disappearing in their turn, were succeeded by a greater degree of pale light, and soon after the near approach of the great luminary himself was announced by a pillar of red orange-red light, which terminated in the orb now appearing large and fiery, through the medium of the horizontal morning air. This is the general course of sunrise in India, as I have often witnessed since. The precursory phenomenon of the *pillar of light*, with the successive changes, being then new to me, appeared perhaps more interesting on that account."

This pillar of light is the *zodiacal light* of astronomers, which we find first mentioned in modern times by Childrans in the year 1559. After his observation had been recorded, it was entirely forgotten until again seen by Cassini on the 18th March, 1683. Since that period its appearance is often recorded by naturalists. Its nature is not well understood. Cassmi, Mairan, Euler, Laplace, Reguier, Hube, and Hahn, have speculated with more or less plausibility in regard to it.

18. *Miasmata.*—Under this name we understand that matter or those matters which, emanating from marshes and other situations where organic bodies are in a state

of decomposition, and received into the human system, produce disease, particularly remittent and intermittent fevers &c. A moderate degree of heat is necessary for the formation of this poison, and also a moderate quantity of moisture. Low situations are more exposed than high ones to miasm, as it is formed at the earth's surface, and as it rises upwards becoming more and more diluted with pure air. Thus the inhabitants of the Compagna di Roma retreat on the approach of the sickly season to the higher grounds, and consider it dangerous to sleep in the lower apartments of a house. Stagnation of the air sometimes allow dangerous accumulations of miasmatous matter; the growth of underwood is very favourable to its accumulation, by breaking and arresting the currents of air, which would otherwise sweep through the forests; and plains without intervening rising grounds, high walls, or trees, are favourable to the diffusion of miasm, by allowing every slight horizontal motion of the air to intermix laterally the pure and contaminated portions of it. Thick ranges of trees, by impeding this horizontal commixture when the air is calm or nearly so, and by altering the direction of light breezes, are very effectual in confining marsh-effluvia. That some kinds of poisonous matters are produced by the decomposition of animal and vegetable substances seems highly probable: others again may emanate from the interior of the earth as the result of subterranean action; and these probably are the most noxious kinds.

19. *Climate.*—British India, situated partly in the torrid and partly in the north temperate zone, is enclosed by boundaries varying much in character,—namely on the west, by the great Western Desert; on the southwest, south-east, and south, by the ocean; on the east, by mountain-ranges; and on the north-east, and north, by the vast Alpine land of Himmalehs,—a mountain-barrier, so elevated as nearly to shut out the atmosphere of India, and thus to secure a meteorological system for itself, different from and independent of that of Indostan. As to form and elevation above the sea, striking contrasts are displayed between the flat lands of the Ganges, the

mountain-chains of the Peninsula, the littoral plains of the Circars, and the table-lands of Mysore. Its surface exhibits sandy deserts, bare rocky plains, extensive cultivated fields, jungles, and dense forests,—traversed by numerous and often considerable rivers, but rarely varied by the appearance of lakes; over which blows, for one half of the year, the south-west monsoon, and during the other half the north-east monsoon, thus affording the conditions for a strikingly-marked climate. The year is divided by the Hindoos into six seasons, but the more common division is into three, viz., the *rainy*, *cold*, and *hot seasons*; the *rainy* in general extends from June to October; the *cold* from November to February; and the *hot* from March to May. Every year there is a variation in the commencement and termination of the seasons, which renders absolute precision impossible in the statement of them. The *healthy season* may be said to be from November to the setting in of the rains, and the *unhealthy season* during the period of the rains, and a short time after their termination. The following short view of the climate of particular provinces will afford to the reader a general conception of the healthiness and unhealthiness of the different provinces of Indostan.*

## I. MADRAS PRESIDENCY.

*The Carnatic.*—The climate of the Carnatic may be generally characterized as dry and hot. The range of the thermometer at Madras is usually from 72° to 92°; but sometimes, during the hot months of May and June, it is as high as 98° and even 105°. In January, February, March, and April, the monthly mean is from 77° to 86°; the extreme variation in each month is usually from 15° to 22°. In May, June, July, August, the monthly mean temperature is usually about 91°, 90°, 88°, and 87°, respectively, the extreme variation being generally from 18° to 23°. During September, October, November, and December, the monthly mean falls progressively from

* The view of the climate of the provinces we owe chiefly to Annesly, Jameson, Young, Brander, and Christie.

85° to 77° or 76°, December being generally the coldest month. The extreme variation in these months is from 13° to 18°. The hot and windy season of May, June, and July, is generally the most healthy: sickness prevails most about the commencement of the monsoon, or from August to November. Sometimes, however, it is greatest in December and January, and at other times in June and July. The prevailing diseases are *fever*, *dysentery*, and *hepatitis* or *liver complaint*.

*Travancore.*—The weather of this province, which is situated at the south-western extremity of the Peninsula, is usually hot. Heavy falls of rain take place between June and December. After these showers the sun generally shines, and produces a disagreeable moist heat. The prevailing diseases among the Europeans are *hepatitis* and *dysentry;* and among the natives, *fevers,* and *ulcers* of the lower extremities.

*Coimbetoor.*—This country is upon the whole healthy, and the houses of the native cultivators more comfortable than in many parts of the Peninsula. *Fevers* are the prevailing diseases, which in some seasons become epidemic, particularly among the natives.

*Malabar and Canara.*—These provinces form the principal part of the Malabar coast, and extend from Cochin to Sadasheveghur. In February the low country becomes extremely hot, and the vapours and exhalations so dense, that it is difficult to distinguish objects at the distance of a few miles. The heats increase during March and April, and with them the quantity of aqueous vapour. On the setting in of the western monsoon in May the whole is condensed into rain. *Fevers, dysentery,* and *hepatitis,* are the prevailing diseases among the Europeans; and *fevers,* and *ulcers* of the lower extremities, among the natives.

*Darwar District.*—The most opposite climates are met with in different parts of the southern Mahratta country; for the western parts, towards the Ghauts, may be reckoned among the wettest of the Indian Peninsula, and the eastern among the driest. The average quantity of rain in the latter is from twenty to twenty-six inches; in

the former a larger quantity often falls within one month. The climate becomes gradually drier as we proceed eastward from the Western Ghauts; and as this chain runs north-north-west and south-south-east, we have consequently a drier climate in the northern parts of the district than in the southern, on the same meridian. Thus, at Soondak the climate is rainy and cool; at Gokauk, on the other hand, which is in the same longitude, it is dry and hot. A considerable quantity of rain falls as far eastward as the country continues hilly; but beyond this the supply is scanty and precarious. In August, 1824, according to Dr. Christie, a good deal fell at Darwar; while, at the same time, not a drop had fallen fifteen miles to the east, and the wells were nearly dried up. For three weeks in July and August, 1827, the rain continued nearly incessant at Darwar, and during the same time not a drop fell in the eastern parts of the district. The difference in the habits and mode of life of the inhabitants of the western and eastern parts of the district abundantly testifies how very opposite are their respective climates. In many places, the former are often for weeks during the monsoon confined to their own villages, not only by the severity of the rains, but, in many instances, in consequence of all communication being stopped by the swollen nullahs. During this dreary period (in anticipation of which a stock of provisions is always laid in) the inhabitants sit round a fire in the centre of their miserable dwellings, which are constantly filled with smoke. When they do venture out, they wrap themselves in a *cumly*,* and over this place "a sort of thatched case or shell, made of the leaves of the *jar*,† or some other of the palm tribe. It is broad over the whole back and shoulders, narrowing to a peak immediatley over the head, and coming down the front over the face just as far as is necessary to give it a firm hold, with a slope sufficient to carry the water that falls on it clear of the body." In the eastern parts it is very different. The rain is seldom so severe as to prevent the inhabitants

* A native blanket. † Borassus flabelliformis.

from going out for four and twenty hours at one time; and precautions against heat, not against cold, are necessary. The villages in the western parts consist of thatched huts, whose steep sloping roofs nearly reach the ground, the walls being only a few feet high, that they may be effectually protected from the rain. Every spot is covered with vegetation. Hedges and trees covered with twining plants line the roads, and the thatched roofs are often concealed by creepers, generally cucumbers, pumpkins, &c. The villages in the eastern parts present a curious contrast to the above Generally not a spot of green, for many months, relieves the horrid glare. All is parched and brown. No protection being required against heavy rain, the houses are built entirely of clay, which one heavy shower, such as the western inhabitants constantly experience, would completely level to the ground. The walls of the houses are formed of sun-baked clay, and are from eight to ten feet high. Upon these is supported a terrace-roof composed of branches of trees or bamboos, and covered with clay. Nothing can be conceived more ugly than these villages. On every side square masses of dry clay give one more the idea of huge ant-hills than of human habitations. In these places, wood being found in too small quantity to serve as fuel, cow-dung is used for this purpose, which, being made into small cakes, is thus plastered on the walls of the houses to dry in the sun. When ready, it is collected into piles like peat-stacks in a Scotch village.

*Mysore.*—The whole of this country has somewhat of the character of a table-land with its accompanying mountains. The elevation varies from 1900 to 4700 feet. The climate, according to Hamilton, is temperate and healthy to a degree unknown in any other tract within the tropics. The monsoons, or boisterous periodical rains, which at different times deluge the coast of Coromandel and Malabar, have their force broken by the Ghauts, and from either side extend to the interior in frequent showers, which, though sometimes heavy, are seldom of long continuence, and preserve both the temperature of the climate and the verdure of the fields throughout the year. The

Island of Seringapatam, on which the capital is built, is under the influenee of both the north-east and south-west monsoons; rainy weather continues from the beginning of May untill the commencement of December. January, February, March, and April, are dry and sultry. From the middle of December till the beginning of February, cold and bleak north-east winds prevail; and between this period and the commencement of the south-west monsoon is the hottest season. The atmosphere is damp, and the dews more or less heavy throughout the year, particularly in January, February, March, and April. The variation of temperature between the day and night is also greatest at this season. The unhealthiest periods are March and April, or a little before the setting in of the south-west monsoon and about the close of October. Bangalore, the principal military cantonment, about 3000 feet above the sea, is one of the most temperate places in the Peninsula. In 1800, the thermometer was observed not to rise higher than 82°, nor to fall lower than 58°.

*Salem and the Baramahl*, which form a part of the table-land above the Eastern Ghauts, have a climate and seasons nearly the same as those of Mysore.

*The Balaghaut, or Ceded Districts.*—This country is elevated, but not so high as Mysore. The weather and climate on the whole are nearly the same as in Mysore.

*Bejapore.*—The climate and seasons resemble those of the Ceded Districts.

*The Northern Circars.*—To the south of Coringa, strong north-east winds prevail along the shore for the first two months of the year, which, together with the sea-breezes, moderate the heat. But where the winds pass over the salt stagnant marshes, as they do in almost every part of the seacoast of this quarter of the province, their influence upon the health is baneful. During March, April, and part of May, high winds from the south-west prevail, and are attended with clouds of dust. In May, June, July, August, and September, the wind generally blows from the west over an extensive parched soil, and hence becomes intolerably hot; so that the thermometer, as formerly mentioned, not unfrequently

reaches 110° or even 112°, and stands above 100° at midnight. In the hilly and more inland parts, the air, owing to the exhalations from the jungles and forests, is unwholesome, particularly in the valleys and ravines by which the hilly districts are intersected. Owing to the great power of the sun in the dry and sandy plains of the south of this province, *coup de soleil* not unfrequently occurs. The diseases are *fever, hepatitis* and *dysentery.*

*Hydrabad.*—This province is a table-land; hence its temperature is lower than the latitude indicates. At the city of Hydrabad, during the cool season, the thermometer is often as low as 40° and 45°. In this district the south-west monsoon usually commences about the beginning of June, and continues with some intervals till the middle of October. During November and December the sky is generally cloudy; the winds easterly; and sometimes when the north-east monsoon is heavy, a considerable qauntity of rain falls. Dews are frequent during January and early in February; but both these months, and March, April, and May, are dry. The mean monthly temperature, in-doors, is stated as follows:—January, 73°; February, 75°; March, 82°; April, 89°; May, 90°, June, 86½°; July, 81°; August, 79°; September, 78°; October, 78°; November, 75°; December, 73°; giving an annual mean of nearly 80°. This is perhaps a little higher than the thermometer placed in a more exposed situation would indicate. The daily range is often very considerable, particularly during November, December, January, and February, amounting in the shade generally to about 20°, and not unfrequently to 30°. *Fevers* and *dysentery* are the prevailing diseases.

*Aurungabad.*—The aspect of the country, the climate, and seasons, are nearly the same in the eastern districts of this province as in the province of Hyderabad.

*Candeish.*—The climate and seasons are here not materially different from those of Aurungabad, or Malwah, to be noticed afterwards.

## II. BOMBAY PRESIDENCY.

The new town of Bombay, the capital of the presidency, is built in a low, muddy, unwholesome tract of land; hence the climate is unhealthy. *Poonah*, a military station and populous city, about thirty miles eastward of the Ghauts and about 2500 feet above the sea, is comparatively healthy. The alternations of temperature are great and sudden. The prevailing diseases are *remittent* and *intermittent fevers.*

*Guzerat.*—Westerly winds prevail the greater part of the year. In May and June they are very hot. During December and January, east and north-east winds prevail, and remarkable thick fogs are generally observed every morning in these months.

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## III. BENGAL PRESIDENCY.

*Bengal.*—The cold season commences, according to Dr. Jameson, with November and ends in February. About the middle of October the weather begins perceptibly to change. The days are still oppressively hot; but the mornings and evenings gradually become cool. The wind, which during the preceding months had blown generally from the south and the east, now begins to come round to the west and north, and to carry along with it those heavy masses of clouds which almost constantly float about and obscure the horizon during the whole of the rains. The atmosphere, from being very damp and watery, grows dry and elastic, and the heavens begin to brighten a little. But these appearances are not yet uniform; the sky still at times becomes gloomy and overcast, and heavy showers, accompanied by thunder and lightning, show that the south-east monsoon has not yet finally taken its leave.

In November, the weather becomes delightfully fair and pleasant. A cold sharp wind now blows steadily from the north, and frequently also from the west. The air is dry, clear, pure, and serene; the vault of heaven is of a beautiful deep azure colour; and, in general, not a cloud

is to be seen. The nights are clear, with heavy dews. The thermometer in the shade ranges throughout the month from 66° to 86°; the mean heat about 74°; medium altitude of the barometer, 29. 98.

As December comes on a considerable change takes place. Although the middle of the day and the afternoon be clear and fine, a haze generally towards evening collects round the horizon, and obscures the setting sun. As the night advances thick fogs, sometimes general, sometimes partial, begin to collect, and do not disperse until morning. As they are broken up by the influence of the sun's rays, their vapours rise and form gray masses of clouds, which render the early part of the day hot and unpleasant, and do not disappear until it is far advanced. These fogs do not by any means occur every night. Sometimes, though rarely, the whole month passes over without them; ordinarily they appear only three or four times; sometimes during several nights sucessively. As in November, the north and west are the prevailing winds. They are very sharp, but blow steadily, never rising to a gale nor falling to a perfect lull. The range of the thermometer is from 56° the 78°; the mean temperature about 70°; altitude of the barometer, 30.01.

During January much the same weather prevails. The air is serene, and to the feel piercingly cold. The wind blows steadily, and perhaps more forcibly, from the north and north-west, than in December. Fogs are still very frequent, and sometimes so thick that scarcely any object is visible until a late hour in the morning; and every thing exposed to the external air becomes wet and covered with drops of moisture. They may be often seen rolling in dense large bodies in opposite directions. During the clear nights heavy dews fall. The range of the thermometer is from 47° to 75°; the mean heat about 68°; altitude of the barometer, 29.99.

The weather keeps very pleasant until the second week of February, when the middle of the day grows warm; and the change of the wind to the south and east, and the collection of clouds in the horizon, with threatenings of

thunder-gusts, portend the approach of the hot season. At night the air is raw and cold, and the mornings are foggy. The thermometer ranges from 65° to 82°; the mean heat, 76°; altitude of barometer, 30.3.

Sometimes a few heavy and refreshing showers fall about Christmas; but the whole of the cold season is generally marked by the total absence of rain. It is remarkable how invigorating the cold bracing wind of the north, and the pure elastic air and clear sky of these months, prove to the European constitution, harassed and broken down by the previous long continuance of moist and oppressive weather. The appetite and strength, which had long before failed; now return, and the whole frame becomes light and springy. Vegetable nature partakes of the generally salubrious effects of the season; and garden-plants and exotics, at all other times killed by the excessive heats, now grow with freshness and vigour.

The hot season may be considered to set in fairly with March. The sun now becomes very powerful, and the days are warm, and even hot. They are, however, prevented from being oppressive by the strong and steady winds uniformly blowing from the south. Fogs are yet not uncommon in the mornings; and as they clear up go to the north to form, with thick dispersed masses of clouds that are constantly drifted along the horizon by the wind, materials for the approaching storms. These storms, which by the inhabitants are termed *north-westers*, do not, however, generally occur till towards the middle and end of the month. They are usually preceded, during several days, by cloudy mornings and strong gales. Then, for one or two evenings, comes on distant thunder, with strong gusts of wind, but without rain. Towards the afternoon of the day in which the storm is to occur, the wind, that, during the morning and forenoon had been continued and boisterous, begins to fail, and at length settles into a dead calm. The air becomes oppressively sultry. The clouds gather in the north-west, and form a deep, dense, lowering bank. Vivid lightning, accompanied with heavy thunder, and gradually advancing nearer and nearer, indicates the immediate approach of

the storm. At length the calm is suddenly interrupted by a tremendous burst of wind, and by clouds of dust which darken the horizon. Then follow torrents of rain, with close and heavy thunder; and these are soon succeeded by a serene sky and cool air. The appearance, however, of these sudden commotions is not always the same. Sometimes a shower of *hailstones* precedes, or comes in the place of the heavy fall of rain; sometimes there is no rain, even when the fury of the wind and quantity of the lightning are excessive. The general time of their coming on is about sunset; they rarely occur earlier than six in the afternoon, or later than midnight. When the days keep clear and the wind moderate, heavy dews fall at night; but in blowing weather there is no dew, the moisture, as it settles, being carried off by the wind. Range of the thermometer, from 73° to 86°; mean temperature, 79°; altitude of barometer, 29.86.

April has generally blowing weather throughout. The prevailing wind is still the south. The atmosphere is sometimes clear, generally hazy, with much dust, and thick low clouds continually moving to the north. The weather is hot, but pleasant, till towards the end of the month, when the nights become close and sultry. The general closeness, however, is from time to time relieved by thunder-storms and seasonable falls of rain. The wind usually becomes hot to the feel about the 20th, and so continues to the end of the succeeding month. Range of the thermometer, from 78° to 91°; mean heat, 84°; barometrical altitude, 29.75.

May is the most unpleasant month in the year. In the commencement there is high wind at times; but during the greater part of the month the weather is exceedingly close, still, and oppressive. The nights especially are sultry. There is little or no wind in the mornings, which are thick and hazy, with low, gloomy, scattered masses of clouds. But as the sun rises a breeze springs up from the south, and keeps gradually freshening until the evening, when it again fades away. The air is hot but inelastic; and as it does not carry off the perspiration, leaves the body moist

and clammy. The dejection and lassitude now universally produced by the great heats are, however, fortunately removed by the frequent occurrence of violent north-westers, with their usual accompaniments of thunder and rain. There are no fogs during April or May. The thermometer ranges from 88° to 93°; mean heat, 86°; barometrical altitude, 29.60. *

In some years, but not always, nor even generally, between the 15th and 25th of this month, the horizon becomes overshadowed with dark thick clouds from the south-east quarter, and much rain falls during several days, constituting what are called the *lesser rains.* But more commonly the close muggy weather continues with little interruption until the end of the first or the beginning of the second week of June, when the veering round of the wind towards the east, the occurrence of thunder in the evening, and the constant cloudy state of the atmosphere, indicate the approach of the regular rains. These commence from the 4th to the 18th of June, and continue with frequent variations during the four following months. At first they set in with thunder-showers, sometimes heavy, sometimes light, generally from the south and east. Then follow several days of very heavy rain, during which the sun is completely hid from view. Then there is a show of fair weather with sunshine, and beautiful clear nights; but this is of very uncertain duration, and liable to be interrupted with scarcely any previous warning. The heavy rain rarely keeps up for more than forty-eight hours at a time; then gradually diminish to drizzling, and at length giving way to fair weather. There is at frequent intervals, during the whole period of their continuance, much vivid lightning, with violent thunder-storms and gusts of wind. The wind frequently changes from east to south and west, rarely to north. Its return to the east, and fixing steadily in that quarter, is usually accompanied with heavy rain.

As soon as the rainy season has fairly commenced, the atmosphere becomes manifestly cooler, and the wea-

* At Chura punji the Thermometer in May does not exceed 72.*

ther in general very pleasant; the only exceptions being now and then a sultry night, and the dead oppressive calm which sometimes precedes a storm. From the dust and other particles floating about in the atmosphere being carried away by the successive showers, the sky during the intervals becomes beautifully clear, the sun shines with great splendour, and the nights are bright. There is very little variation of the atmospherical temperature throughout the season. The thermometer ranges from 77° to 88°, or 90°; the mean heat being 81°. or perhaps a degree or two higher. The air, from the constant rain, becomes surcharged with moisture, and every thing exposed to it gets damp and mouldy. There is consequently little alternation in the barometer. The mean altitude is about 29.45.

There is little perceptible change in the weather till the middle of October. The rain then begins to abate, the showers are fewer in number, and, though heavy, of short duration. The wind gets very variable. There are still frequent storms of thunder and lightning; but they generally pass off without producing rain. The days are yet sultry; but the mornings and evenings begin to grow cool; and the increasing clearness of the air, with the coming on of dews at night, presage the speedy accession of the cold season. At length the veering round of the wind to the west-north-west quarter, the disappearance of clouds and vapours from the horizon, the sharpness and dryness of the air, the rapid rise of the barometer and concomitant fall of the thermometer, towards the end of the month, evince the entire departure of the rains. The total quantity of rain falling during the season varies much in different years. In Bengal, the average hes been fixed at eighty inches.

*Bahar.*—The seasons are nearly the same in this province as in Bengal; but, as it is higher above the sea, its climate is in some respects superior. The nights are generally much cooler; but it is more subject to great droughts and heat, and to parching winds from the west, during the warm season. Tirhoot, the north-western quarter of this province, is more elevated and healthier

than the districts to the south. On account of the soil and climate, Bahar has been selected by the British government as a proper country for the improvement of the breed of horses, the native race of the Bengal province being of a diminutive size. A low and marshy soil, it is remarked, seems every where uncongenial to the horse; for he appears to degenerate in such places, even when he lives and propagates. In districts in warm climates which are more than usually low and marshy the horse generally experiences the fate of the Europeans; he either dies soon after he is brought to those places, or his progeny seldom reach maturity.

*Allahabad.*—That part of this province adjacent to the Ganges and Jumna is low and very productive; but its western districts, particularly the Bundelcund territory, are diversified with high hills. Between these two divisions there is a considerable difference of climate, the former being sultry and subject to hot winds, from which the latter is exempt. Benares, the principal military and civil station, contains, according to the census of 1830, upwards of 200,000 inhabitants. The cantonments, which are extensive, are four or five miles distant from the city. The country around is dry and parched. *Fever* and *dysentery* are most prevalent during October, November, and December, owing to the inundations from the previous rains and the cold nights.

*Oude.*—This province is generally level and well cultivated, with the exception of Gorucpoor. It is, on the whole, healthy, except in the vicinity of jungles and cotton-fields. The district of Gorucpoor is bounded on the north by a range of lofty mountains. The country extending southward from the base of these mountains is flat, covered with woods and jungles, and intersected by numerous streams. Easterly winds prevail generally throughout the year. The climate is far from being healthy, owing to the great extent of jungle, stagnant water, and marshes, over which the easterly winds pass before they reach the more inhabited parts of the country. Fevers are most prevalent and dangerous in May and June.

*Agra.*—This province is generally flat and open; but to the south of the Chumbul river, and towards its western frontier, it is more hilly and jungly The climate is temperate and healthy, except during the prevalence of hot winds.

*Delhi.*—The climate of this province is on the whole temperate, except during the warm seasons when the hot winds blow. The north-west quarter is much overgrown with trees and thick jungle, and is consequently unhealthy, especially during the hot and rainy seasons. The south-west quarter is free from jungle, and its soil is dry and fertile. The centre of the province is level and well watered. Meerut, the principal town of the district of the same name, is considered one of the healthiest stations in India. Mr. Jackson strongly recommends it as a place of residence for convalescents, and for those who have become naturalized to India, and estranged from their own country. The society is extensive, and the roads good.

*Malwah and Central India.*—The climate of Malwah is on the whole mild. The range of the thermometer is small, except in the latter part of the year, when great and sudden changes often take place. The seasons are those common to Western India. The fall of rain during June, July, August, and September, is in general moderate and regular. The annual fall is about fifty inches. During this season, says our distinguished countryman Sir J. Malcolm, "the range of the thermometer is very small, seldom falling lower than 72° night and morning, or rising higher than 76° or 77° at noon. Though the mornings become cooler after the close of the rainy season, there is no very cold weather until the month of December; it continues until January and part of February. In the latter month, in 1820, at six o'clock A. M., the temperature was 28°. During the hot season which succeeds, the parching winds from the northward, and westward, that prevail in most parts of India to an intense degree, are here comparatively mild and of short duration. The thermometer, however, during the day rises sometimes as high as 98°; but the nights are invariably cool and refreshing."

*Bagur* is a hilly region, situated between Malwah and Guzerat. Owing to its extensive and thick forests, fevers of a malignant nature prevail during two or three months following the rains: the climate can at no period be considered salubrious.

*Gundwana* is a vast wild region, consisting of rugged hills, uninhabited jungles, and deep water-courses, ravines, and valleys, covered with forests, and pervaded by marsh miasmata. Its climate is generally unhealthy.

*Orissa* has many features in common with Gundwana, and a similar climate.

*Himmaleh Mountains.*—The climate of the valleys and ridges of this vast mountainous country is, as already stated in our observations on the height of the snow-line, much milder than we were led to expect from the conjectures and calculations of philosophers,—vast tracts, which according to their views ought to be steril in the extreme, or eternally covered with snow, are, on the contrary, richly clothed with vegetation, abounding in animals, and animated by villages. Thus Marang, a large village surrounded by lofty mountains, though 8500 feet above the sea, enjoys a mild climate. During eight days spent there by Captain Gerrard, the temperature varied from 58° F. to 82° F.; and flies were very troublesome. The sun, even in July, was scarcely visible above the mountains before 8 A. M., and disappeared behind them at 5 P. M. There were alternately light clouds and sunshine, and now and then a little rain, which in this valley never falls heavy; the height of the outer chain of the Himmalehs being sufficient to exclude the rains that deluge India for three months. Mr. Colebrooke, speaking of Zoncheng, a village among these mountains whose height is 14,700 feet, which in latitude 31° 36′ N., according to received theory, should be buried in everlasting snow, assures us that the case is far different. On every side of the glen, which is a bowshot across, appeared gently sloping hills, for the most part covered with *támá* or Tartaric furze. The banks of the river were covered with grass-turf and prickly bushes. Around, the land was covered with verdure; flocks of sheep were

browsing, and deer leaping; altogether it was a romantic spot, wanting but trees to make it delightful. Gerrard, on the crest of the Húkëtó pass, 15,786 feet high, observed yaks and horses feeding on the surrounding heights; and the climate was pleasent, the temperature being 57° F. On Zinchen, which is 16,136 feet high, and on the neighbouring mountains, horses were observed galloping about in all directions, and feeding on the very tops of the heights; kites and eagles were soaring in the air; large flocks of small birds like linnets were flying about, and locusts jumping among the bushes. The climate is very different from that experienced in crossing the outer range of the Himmalehs at the same season. Here, at the height of 16,000 and 17,000 feet, is abundance of fuel (*metóh,* bearing a beautiful yellow flower and no prickles), good water, and a serene sky; there at an *inferior elevation* no firewood is nearer than five or six miles, the clouds hang around the mountains, the sun is scarcely visible, and showers of rain are frequent. At the village of Pùi, at an elevation of 13,600 feet, there are cultivated fields of barley, *phàpur,* and turnips. A little lower the ground was covered with thyme, sage, and many other aromatic plants, besides juniper, sweet-brier, and gooseberries. Here also are vineyards and groves of apricots.* At Dabling there was much cultivation, with plantations of apricots and walnuts. During Captain Gerrard's residence here (August), the temperature was warm, varying from 61° F. at sunrise to 85° at noon, the wind blowing strongly from the south-west, and the sky frequently obscured with light clouds attended with little rain. Near the village of Nákó, in the midst of these mountains, situated 12,000 feet above the sea, in the heart of an abundant population, he found the grain "already yellow, with a broad sheet of water, surrounded by tall poplar, juniper, and willow trees, of prodigious size, and environed by massive rocks of granite. Here are produced most luxuriant crops of barley, wheat,

* The apricots form a part of the subsistence of the people. At this season they are pulled, and exposed to the sun on the roofs of the houses; when dried they are not unlike prunes.

*phàpur (polygonum)*, and turnips, rising by steps to nearly 700 feet higher than the village, where is a lama's residence, inhabited throughout the year. The fields are partitioned by dikes of granite. At Taz-hi-gang they are enclosed by barberry and gooseberry bushes."

The seasons at this great elevation are similar to those of our northern latitudes, the grain being sown in March and April, and reaped in August and September. Snow generally falls towards the end of October. It seldom exceeds two feet in depth, but does not leave the ground for nearly six months. Want of moisture in the air prevents its earlier descent (since the beginning of October is winter) under a clear sky. In the middle of October, 1818, the thermometer at sunrise was seldom above 20° F.; in August the temperature was 75° F. at noon, and never below 52° F.

20. *Sanitary Depôts.*—It having been found that those suffering under the diseases of the lower and hotter parts of India had their health improved by a residence in the hilly districts, the government have of late established sanitary depôts in several of the hill-provinces. Not many years back, the Mount of Saint Thomas, near Madras, was considered the Montpelier of the south of India. After the fall of Seringapatam, and the consequent occupation of the table-land of Mysore by the British troops, the cantonment of Bangalore became the general resort of all classes whose health required a change of climate. Now the Nhilgerry mountains, in the same division of India, are considered as affording a healthier climate; and there the government have established a sanitary depôt. The greatest length of the Nhilgerries Proper is from east to west thirty-six miles, and the medium breadth fifteen miles.

Although only twelve degrees distant from the equator, and surrounded by plains where the thermometer not unfrequently stands in the shade at 100° F., yet, from its elevated situation, it possesses a mildness of climate not inferior to the temperate parts of Europe, and also a great equability of temperature, which renders it so beneficial in many diseases. During a great part of the

year, says Mr. Young, the range of the thermometer on the Nhilgerries is less than is known in any part of the globe; and during December, January, and February,—the season of the greatest cold,—it has never been known to exceed 28° F., the greatest heat 59° F., including, between the extremes, a temperature which has always been found congenial to the European constitution, and very different in its effects from similar oscillations at a higher temperature, as exhibited in all parts of the Deccan and throughout India generally. During the rainy season the thermometer varies but little,—the range has been so low as 2½° for a whole month. Except the three cold months, the range will generally be from 2½° to 6°, or at most 10°, making the climate one of the most equable on the earth; and consequently very favourable to persons of a consumptive habit. Invalids, on reaching the hills in the cool season, feel the air of the mountains too rigorous; but to the healthy it is the period of the greatest enjoyment, when they can wander through the woods in search of game, and almost forget that they are still exiles from their own country. The only winter on these mountains is experienced during this period; the grass which covers the downs and elevated ridges becoming yellow and seared; but the moment the frosts are over, about the end of February, the country quickly assumes its verdant appearance, and the duties of the husbandman re-commence just as the plains below are beginning to feel the desolating effects of the hot winds. The climate of the Nhilgerries may, in some measure, be considered a perpetual spring; vegetation is slow and steady except during frosts. Notwithstanding the lowness of the thermometer during the whole year, sick persons cannot without risk expose themselves to the sun from 10 A. M. till 4 P. M.; and as the mornings are very agreeable, they are recommended to take exercise either on foot or horseback from 6 till 9 A. M., and from 5 till 7 P. M., confining themselves in the middle of the day, except during the delightful intervals of fine weather which prevail during the rains, when they may walk out at all hours with advantage. This precaution is only intended

to apply to a state of actual sickness or debility; for persons in rude health may get out at all times and seasons. During March, April, and May there are refreshing showers. The temperature in the sun's rays exhibited to Mr Young an excess of from 25° to 12° above what the indications were found to be in a veranda out of the sun's rays.

Should future experience confirm the accounts of the sanitary virtues of its climate, this mountainous region, says Mr. Young, may become an asylum for such as have lost their health in other parts of India, not only superseding expensive voyages to the Cape and the Isle of France, but in many cases a trip to the mother-country. To such of the civil and military servants of the India Company as have outlived all their relations and friends in Europe, and to whom a return thither would amount to a melancholy species of banishment, the Nhilgerries present a delightful asylum for the remainder of their lives,—a sort of Eurasian climate, and within a moderate distance from the friends of their adopted country, many of whom they may expect to see on the hills.*

A report has lalety been published in regard to a Sanatarium for the Calcutta district at *Dargeeling* in the Sikkim mountains. The travelling distance of Dargeeling from Calcutta is about 330 miles. It is situated on one of the numerous branches of the Sinchul mountain, elevated nearly 9000 feet, and forming a remarkable feature in every view of the Sikkim hills from the plains. Captain Herbert, who visited the spot on the part of the government, is of opinion that the climate, salubrity of the approaches, and the convenience of the situation, all speak in its favour. Its elevation above Calcutta is 7218 feet, and its mean temperature is calculated to be 24° below that of Calcutta, and only 2° above that of London (52°).

Accommodation for invalids has been provided at *Simla*, a station among the hills between the Sutledge and Jumna near Subhatoo, and 7500 feet above the sea. Even the winters here are much less rigorous than in England, with the advantage of powerful solar radiation, which is said to increase as we ascend higher on the mountains.

* See a further account of these hills in the 3rd vol. of the Journal of the Asiatic Society, page 650.

*Pooree*, which can be reached by sea at all seasons from Calcutta in two days, is a station whose pure and invigorating air, together with its equable climate, render it one of the most salubrious spots in the East. Dr. Brander says, the best months for convalescents residing at Pooree are February, March, April, May, and the early part of June, which, as they are found to be the months apparently the most trying to the European constitution in other parts of India, become, in a ratio corresponding with the difference of temperature and other local advantages, relatively the most healthy and and the best suited to a sojourn on the coast. At that period the south-west monsoon prevails, and seems to exert with greatest effect its prophylactic influence over the convalescent visiter, who is not a little gratified to find, instead of the *tatties* and artificial refrigeration necessarily employed at inland stations, a never-failing source of cool air in the renovating sea-breezes. Although a preference has been assigned to the above months, it is not easy, in a climate on the whole so uniform as this, to point out with precision the period of the year that may be considered as the healthiest; the most agreeable, and probably the most congenial to the feelings, are the months comprised between October and February inclusive, when the thermometer ranges between 64° F. and 76° F. The extremes of temperature during the twelve months are 64° and 89°, subject to very little variation during the twenty-four hours. June, July, August, and September, may be considered as the unfavourable months. Seeing how entirely remote Pooree is from the sources of disease peculiar to inland stations, the salubrity and uniformity of its climate, its ready access at all periods of the year, and farther, the benefits the voyage holds out to the invalid and those sinking under tropical disease, it is probably difficult, with such available advantages, to fix upon any spot better suited for a *sanaturium* or convalescent retreat, than the one under consideration; a visit to which might, in many instances, preclude the necessity of undertaking voyages to Europe or the Cape,—performed frequently with considerable sacrifice and inconvenience.

A Table exhibiting the Monthly and Yearly Mean Temperature of the Air at Calcutta, Bombay, Madras; at three several Elevations on the Nhilgerries; at the Cape of Good Hope, New South Wales, and the City of London; with Average Falls of Rain in England and the Nhilgerries.

| | Calcutta. | | | Bombay. | | | Madras. At the Observatory. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean Maximum. 3 P. M. | Mean Minimum. 6 A. M. | Mean Temperature. | Mean Maximum. 4 P. M. | Mean Minimum. 11 A. M | Mean Temperature. | Mean Maximum. | Mean Minimum. | Mean Temperature. |
| January... | 75.1 | 63 | 69.05 | 78 | 76 | 77 | 82.2 | 74.1 | 78.15 |
| February.. | 80 | 67 | 73.5 | 78 | 76 | 77 | 84.5 | 73.8 | 79.15 |
| March .... | 88.1 | 78 | 83.05 | 81 | 80 | 80.5 | 87.6 | 78.7 | 83.15 |
| April. .... | 95.1 | 79.1 | 87.1 | 84 | 83 | 83.5 | 92 | 84.1 | 88.05 |
| May.. .... | 97.1 | 80.1 | 88.6 | 85 | 85 | 85 | 94.3 | 85.1 | 89.70 |
| June...... | 88 | 78 | 83 | 86 | 85 | 85.5 | 90.5 | 84.2 | 87.35 |
| July...... | 86.1 | 78.1 | 82.1 | 81 | 81 | 81 | 92.6 | 85.3 | 88.95 |
| August ... | 86.2 | 79.3 | 82.75 | 84 | 84 | 84 | 89.9 | 83.1 | 86.50 |
| September | 86 | 78 | 82 | 80 | 79 | 79.5 | 89.7 | 83.3 | 86.50 |
| October... | 85.2 | 76.1 | 82.65 | 85 | 84 | 84.5 | 87.8 | 82.4 | 85.10 |
| November | 79 | 65.2 | 71.6 | 85 | 84 | 84.5 | 84.3 | 80.1 | 82.2 |
| December | 75 | 59 | 67 | 81 | 80 | 80.5 | 80.2 | 76.0 | 78.1 |
| An. Means | 85.3 | 73.1 | 79.37 | 82.3 | 81.4 | 81.9 | 88.0 | 80.8 | 84.4 |

| | The Nhilgerries. Serloo, 3400 feet above the level of the Sea. Monthly Means. | | | Jackanary, 8500 feet above the level of the Sea. Monthly Means. | | | Ootacamund, 8500 feet above the level of the Sea. Month. Means. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean. | Range. From | Range. To | Mean. | Range. From | Range. To | Mean. | Range. From | Range. To | Average fall of Rain for two years. Inches |
| January... | 66¾ | 83 | 54 | 56¾ | 64 | 49 | 50¼ | 59 | 31 | 1.17 |
| February.. | 67¼ | 94 | 58 | 55¾ | 65 | 43 | 51¾ | 63 | 39 | — |
| March .... | 72 | 99 | 64 | 61 | 68 | 41 | 61 | 65 | 55 | 2.47 |
| April. .... | — | — | — | 63¼ | 72 | 54 | 61¼ | 64 | 57 | 3.10 |
| May.. .... | 74 | 89½ | 65¾ | 63 | 71 | 58 | 61¼ | 65 | 57 | 5.21 |
| June...... | — | — | — | 62½ | 66 | 59 | 59 | 64 | 50 | 5.25 |
| July...... | — | — | — | 63¼ | 73 | 57 | 56¼ | 66 | 49 | 10.37 |
| August ... | — | — | — | 63½ | 75 | 55 | 58 | 63 | 48 | 11.77 |
| September | — | — | — | 57¾ | 73 | 46 | 57¾ | 69 | 49 | 2.40 |
| October... | — | — | — | 61 | 68 | 52 | 56 | 64 | 44 | 7.41 |
| November | — | — | — | 56¼ | 66 | 44 | 54¾ | 63 | 43 | 10.86 |
| December | — | — | — | 58¼ | 66 | 48 | 51½ | 63 | 37 | 3.87 |
| An. Means | 70 | 91.37 | 60.11 | 60.1 | 68.9 | 50.7 | 56.6 | 64 | 46.58 | 63.88 |

| | Africa. Cape of Good Hope | | Australasia. Sidney, New South Wales. | | | England. London for 1819—20 and 21, from Daniell's Meteorological Essays. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean Temperature. | Range. | Maximum. | Minimum. | Mean Temperature. | Mean Maximum. | Mean Minimum. | Mean Temperature | Range. From | Range. To | Average fall of Rain for two years |
| January... | 76 | Greatest heat 90° in January, and lowest 45° in August, 1819. | 102 | 47 | 74 | 39.6 | 32.6 | 36.1 | 52 | 11 | 1.483 |
| February.. | 79 | | 106 | 52 | 73 | 42.4 | 33.7 | 38 | 53 | 21 | .746 |
| March .... | 75 | | 97 | 49.5 | 68.5 | 50.1 | 37.7 | 43.9 | 66 | 21 | 1.440 |
| April. .... | 67 | | 98 | 49.5 | 60 | 57.7 | 42.2 | 49.9 | 74 | 29 | 1.786 |
| May.. .... | 62 | | 72 | 42 | 60 | 62.9 | 45.1 | 54 | 70 | 33 | 1.853 |
| June...... | 57¾ | | 67 | 26 | 53 | 69.4 | 48.1 | 58.75 | 90 | 37 | 1.830 |
| July...... | 57¾ | | 68 | 27 | 51.5 | 69.4 | 52.9 | 61.1 | 76 | 42 | 2.516 |
| August ... | 60 | | 77 | 35 | 56 | 70.1 | 52.9 | 61.5 | 82 | 41 | 1.153 |
| September | 63 | | 86 | 37 | 62 | 65.6 | 50.1 | 57.8 | 76 | 36 | 2.193 |
| October... | 63 | | 93 | 36 | 62 | 55.7 | 42.1 | 48.9 | 68 | 27 | 2.073 |
| November | 73¼ | | 106 | 42 | 63 | 47.5 | 38.3 | 42.9 | 62 | 23 | 2.400 |
| December | 75 | | 99 | 18 | 72 | 43.2 | 35.4 | 39.3 | 55 | 17 | 2.426 |
| An. Means | 67.39 | — | 80.2 | 40.9 | 62.9 | 56.1 | 42.6 | 49.35 | 68.7 | 28.4 | 22.199 |

RECAPITULATION.

Mean Temperature in London, ... ..... .. 49.35°
——— at Serloo............ 70
——— at Jackanary,...... .. 60.1

Mean Temperature at Ootacamund........ ..... 56.6°
——— in New South Wales,......... 62.9
——— at the Cape of Good Hope,..... 67.39

Mean Temperatnre at Madras,......... 84.4°
——— at Bombay,......... 81.9
——— at Calcutta,... .... 79.37

# CHAPTER II.

## HYDROGRAPHY.

Springs—Hot Springs—Wells—Lakes—Rivers—The Ganges—Length of the Rivers of India—Cataracts.

*Springs.*—Although India, like other great tracts of country, contains many springs, these have hitherto attracted but little attention. The temperature of but few of them is known; their magnitudes and geognostical situations are scarcely ever mentioned; and their chemical composition, excepting in a very few instances, has been neglected. The most important feature in the natural history of *common* or *perennial* springs, namely their temperature, is rarely noticed, although a knowledge of this fact is illustrative, not only of the mean temperature of the climate, but also of the elevations of the land above the level of the sea; and our information in regard to their chemical nature is equally meagre.

*Salt Springs*, although met with in saline soils, in some instances probably connected with a salt formation, might be shown to exhibit interesting relations; yet they are not so curious in a general view as the hot springs in different parts of India, concerning which the following details are worthy of being communicated to our readers.

*Hot Springs.*—The appearance of hot springs in a country never fails to interest the geologist, because, independently of high temperature and other properties, their intimate connexion with igneous rocks and distorted conditions of the strata, shows not

only that a subterranean heat still exists, to which they owe in some degree their elevated temperature, but also that they may have burst forth during some early subterranean igneous action.

They occur among the primitive and secondary strata of the Peninsula, and flow from primitive and transition rocks in the Himmalehs. Thus Heyne says he heard of a hot spring situated in the middle of the river Godavery, near Badrachellum, about 100 miles west from Rajahmundry. Spilsbury mentions two hot springs in the valley of the Nerbudda, at the northern base of the Mahadeo hills. They are much resorted to; not indeed for medicinal purposes, but principally as a place of *pooja* or worship, though people bathe at times for the cure of cutaneous disorders. At both a sort of reservoir has been constructed; but the western spring, near Sohagpoor, is the only one that can be bathed in; and even its heat is too great to allow a person to remain in it above a few seconds, while the eastern one is so hot that the hand can scarcely be dipped in it. Both emit a very offensive smell at the spring head; but the water from the western, on cooling, almost totally loses this smell; whereas that from the eastern, or one near Futtypore, retains it a long time. A lamp held over the place where the west or Unhonee spring bubbles up, is immediately extinguished; and at about five or six paces off is a cold spring. In a paper by the late Dr. White, lately read before the Royal Asiatic Society, mention is made of hot wells situated about fifty miles south-east of Surat. The temperature of one is 111° F., of another 120°. Mr. H. Wilson notices hot springs in Ramghur, that flow from the base of the *granite* table-land of Hazareebagh. There are four springs at the spot, varying considerably in temperature; the water of one is at the temperature of the atmosphere, that of another is 108° F., whilst that of the other two is severally 170° F. and 178° F. From the last of these arises much sulphureted hydrogen, the odour of which continues

to be felt long after the water is cool. The water yields a copious residuum upon evaporatioa, having as its chief ingredients muriate and sulphate of soda, with a very slight indication of sulphate of iron. It is not unpleasant to the taste, and the cattle are said to be very fond of it. When drunk in sufficient quantity it acts as a gentle aperient. Captain Franklin mentions a hot spring flowing from *new red sandstone*, near the river Bagin, in the Pana diamond-district in Bundelcund. In the neighbourhood of Uteer, a village about thirty miles distant from Pooree, there is a hot mineral spring; but Dr. Brander, who mentions it, gives no details in regard to its temperature. Setacuno on the Ganges, according to Dr. Adam, is celebrated on account of its hot spring, which, like those in Southern Africa, described in a volume of the Edinburgh Cabinet Library, issues from *quartz rock*. This spring is about 500 or 600 yards from the river. When Dr. Adam visited it in November, it was running in full stream; but before and during the early part of the rainy season he was told it always dried up, and when low indicates merely the common temperature. He found the sensation of heat intolerable when the hand was immersed in it, and the thermometer stood at 140° F. at all parts, as well near the surface as within a few inches of the bottom. Excepting the increase in the temperature, this water possesses no sensible properties different from rain or common spring water; it is clear and tasteless: gas was constantly disengaged from the surface in large bubbles, but the nature of the gas has not been determined. Many virtues are attributed to the waters in the cure of diseases; and the Bramins, who take charge of it, derive cosiderable emolument from the crowds resorting thither for relief. Mr. Ludlow describes a hot spring at the town of Sonah, about thirty-five miles west from Delhi and fifteen from Goorgaon, at the eastern face of the Mewat hills, which are of *sandstone*, with dispersed iron ore. Close to one of the most craggy and precipitous of this range is the spring in question, which issues out of a hollow dug in the rock. The water, being at a temperature of 108° F., is seen

bubbling up, abundantly charged with gas and so impregnated with sulphur as to diffuse a strong smell through that part of the town in which the spring is situated. The well is cut out of the solid rock, about thirty feet deep, in the centre of a basin sixteen feet square, with steps leading down to the water for the convenience of bathing. The whole is covered by a beautiful dome of ancient architecture, and surrounded by apartments with open verandas, which form a court or area. Mr. Ludlow says the water contains no iron, and may be classed with the strongest of the sulphureous waters.

At Jauvi, on the northern bank of the Sutledge, eight or ten hot springs burst forth a few feet from the river. A thermometer plunged into one of them rose to 130½° F., while the temperature of the river at the time, the 1st of October, was 61°. The water has a sulphureous smell, with a very disagreeable brackish taste, and incrusts the stones with a yellowish matter resembling sulphur. Gerrard noticed hot wells among the mountains at the head of the same river, 13,000 feet above the level of the sea. A *range* of hot springs, which threw up clouds of steam, was observed by Captain Hodgson toward the head of the Ganges. The same enterprising traveller discovered, in the upper part of the Jumna, hot springs at Oetha-Gur, Bannassa, and Jumnotree; at the last-mentioned place an arch of snow forty feet thick extends across the nascent stream, and completely conceals the ravine from which it takes its rise. Under this arch are numerous hot springs. Their vapour melts the snow from below upwards, so as to form cavities and arches, while the snow is perpetually falling from above. The temperature of the water, where it issues from the rock, is 194° F., which, considering the elevation, 10,849 feet, is nearly the boiling point of water. These springs issue from rocks of *granite* and deposite oxide of iron. Some of them are spouting, being projected upwards in columns of considerable magnitude. They are of great sanctity; and at a spot used for bathing a considerable one rises in a pool of the river, and renders it milk-warm. This jet is both seen and heard as it plays under the surface.

Where the Soar and the Elgie flow towards the Ganges, there occurs on the opposite bank of the former a series of hot springs, said to issue from *primitive rocks.**

*Wells.*—On sinking pits or shafts, we in most districts at length reach some reservoir, from which water rises upwards and forms wells. Owing to the peculiar nature of the climate in many parts of India, wells are of vast importance in supplying the deficiency of rain. In the Balaghaut country, or the country between the Krishna and Toombuddra in the north and the Mysore on the south, when taken possession of by the British, fifty thousand wells were reckoned. Even in the great Western Desert, wherever pits are sunk to a sufficient depth, water is met with. These wells in the Desert are often 300, and one was observed 345 feet deep; with this enormous depth some are only three feet in diameter. The water, which is always brackish, unwholesome, and so scanty that two bullocks working for a night with ease empty a well, is poured into reservoirs lined with clay, which Mr. Elphinstone's party drank dry almost in an instant after their arrival. The wells are lined with masonary. The natives have a method of covering them with boards heaped with sand, that effectually conceals them from an enemy; so that scarcity of water is at once their wo and protection. Mr Elphinstone notices a magnificent well of fine water under the walls of the fort of Bikaneer, 300 feet deep, and fifteen or twenty-two feet in diameter. Four buckets, each drawn by a pair of oxen, were worked at once; and when a bucket was let down its striking the water made a noise like a great gun. In India, as in other countries, water might be brought from below in such quaintity as to fertilize arid and desert tracts, especially if advantage were taken of the clay and marl so often met with during the sinking of shafts and pits.

A curious mode of sinking wells is mentioned by Heber, as being employed by the natives of the country between

* C. Betts Esq. discovered a hot spring in the river Damuda, about 6 miles from the Pachete Hills. The heat is 190° Fah. The spring is slightly chalybeate.

Agra and Jeypore. They build a tower of masonry of the diameter required, and twenty or thirty feet high from the surface of the ground. This they allow to stand a year or more, till its masonry is rendered firm and compact by time, then gradually undermining it, the whole tower sinks without difficulty into the sandy soil. When level with the surface they raise its wall higher, and so go on throwing out the sand, and raising the wall, till they have reached the water. If they adopted our method, the soil is so light that it would fall in before they could possibly raise the wall from the bottom; nor without the wall could they sink to any considerable depth.

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## LAKES.

In India the waters of the land are principally distributed in the form of rivers and springs, lakes being of but rare occurrence, and the few that do appear of inconsiderable size. Some of these lakes are salt, others fresh, and a few owe their chief characters to carbonate of soda.

*Salt Lakes.*—A *salt lake*, twenty miles long by one and a half broad, occurs near Samber, a Rajpoot town in north latitude 26° 53′, and longitude E. 74° 57′. The salt from this lake supplies a considerable portion of Upper India, and during the Mogul government it was carried as far as Benares and Bahar. Every year after the rains the water becomes so strongly impregnated, that when the lake dries up the salt is found crystallized in large quantities under a layer of mud. It is collected towards the close of the hot season without having undergone any artificial process; it is then spread out and exposed to the sun for ten or fifteen days, in which space of time it hardens and forms large lumps; on these lumps a quantity of dry grass is placed and set fire to, which calcines the external surface and forms a covering sufficiently hard to resist the rain. In this last state it is sold, and reaches the different markets. There are many other salt lakes in this part of India, as those of Didwana

and Ser; indeed, the soil throughout India is so impregnated with salt, that it is very rare to see a hollow or low spot without a saline efflorescence on the surface.

In Berar there is a salt lake named Loonar, which, according to Captain Alexander, lies in a sort of cauldron of rocks. It contains in the 100 parts, muriate of soda 20, muriate of lime 10, muriate of magnesia 6. The chief use to which the sediment is applied is cleansing the shawls of Cashmere. It also froms an ingredient in the alkaline ley of the Mohammedans. High in the Himmalehs, towards the sources of the Indus, salt lakes were observed by Mr. Garrard at an elevation of 16,000 feet. Natron or soda lakes are said to occur in certain parts of the Himmalehs.

*Fresh Water Lakes.*—A large *fresh water* lake, or rather jeel named the Colair Lake, formed chiefly of the overflowings of the Krishna and Godavery, is situated at the north-east projecting corner of the Condapilly Circar, about five miles south from Ellore, whence the water is conducted into many channels to irrigate the circumjacent country. Its breadth, according to Hamilton, varies from seven to twelve miles, while its extreme length may be estimated at twenty-two miles, covering an area of about 164 square miles. On a failure of the periodical supplies the lake dries up, and drinkable water becomes so scarce that the poorer inhabitants are compelled to migrate, and suffer privations almost equal to famine. Magnificent artificial fresh water lakes, formed by dykes built across rivers, are described by Dangerfield as occurring in Mewar. The lake of Cashmere and that of Manasawara in Thibet, although in many respects interesting, do not properly belong to India.

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## RIVERS.

The rivers of India may be classed under two divisions, viz. those that flow from the Himmalehs, and those that take their rise in the mountains of the Peninsula.

They carry with them to the ocean not only a vast body of water, but an enormous quantity of the debris of the lands through which they pass. The Himmaleh rivers, as the Indus, Ganges, and Brahmapoutra, obtain their supply of water partly from the snows and glaciers of the mountains, and partly from the rains of the monsoons; while those of the Peninsula are entirely supplied by the monsoon rains. The rivers most celebrated in history and geography are the Indus, Brahmapoutra, and Ganges; the latter is the most important to India as a great province of the British empire. From its elevated source, nearly 15,000 feet above the level of the sea, the Ganges winds through mountainous regions for fully 800 miles, and issues into the open country at Hurdwar, in latitude 30° north. During the remainder of its course to the sea, which is about 1350 miles, flowing as a smooth navigable stream through delightful plains, it receives eleven great rivers, some of which are equal to the Rhine, and none smaller than the Thames, besides as many others of lesser magnitude. It is owing to this vast influx of streams that the Ganges, in point of magnitude, so greatly excels the Nile, whilst the latter exceeds it in length of course by one-third. Like the Nile it has a vast Delta, which exhibits the usual characters of such alluvial formations. To the natives the *inundations* of this river are equally objects of interest, as are those of the Nile to the Egyptians. These annual overflowings of the Ganges are owing as much to the rains and to the melting of the snow among the mountains beyond Hurdwar as to the rains that fall in the plains; for at the latter end of June the river has risen fifteen feet and a half, out of thirty-two, the sum total of its rising; and it is well known that the rainy season does not begin in most of the flat countries till about that time. In the mountains the rains commence early in April, and near the latter end of that month, when the rain-water has reached Bengal, the rivers begin to rise, but by very slow degrees; for the increase is only about one inch per day for the first fortnight. The increase then gradually augments to two and three inches, before any quantity of rain falls in

the flat countries; and when the rain becomes general, the increase on a medium is five inches per day. Before the end of July all the lower parts of Bengal contiguous to the Ganges and Brahmapoutra are overflowed, and form a lake of more than 100 miles in breadth; nothing appearing but villages and trees, excepting very rarely the top of an elevated spot, or the artificial mound of some deserted village rising like islands in the flood.

The inundations in Bengal differ from those in Egypt in this particular, that the Nile owes its floods entirely to the rains that fall in the mountains near its source; but in Bengal they are as much occasioned by the rain that falls in the country itself as by the waters of the Ganges; and as a proof of this, the lands in general are overflowed to a considerable depth long before the bed of the river is filled. It may be remarked that the ground adjacent to the bank, to the extent of some miles, is considerably higher than the rest of the country, and serves to separate the waters of the inundation from those of the river until it overflows.* The high ground is in some seasons covered a foot or more; but the depth in the lower country varies, of course, according to the irregularities of the ground, and is in some places twelve feet. Even when the flood becomes general, the river still shows itself, as well by the grass and reeds on its banks as by its rapid and muddy stream; for the water of the inundation acquires a blackish hue, by having been so long stagnant amongst grass and other vegetables; nor does it ever lose this tinge, which is a proof of the predominancy of the rain water over that of the river. The slow motion of the inundation, which does not exceed half a mile per hour, is owing to the flatness of the country.

There are certain tracts of land which require less moisture than others, from the nature of their productions; these are defended from the floods by vast dykes, which are kept up at an enormous expense. One branch of

* This property of the bank is caused by the deposition of mud from the waters of the river when it overflows. The inundation, as Buffon remarks, purifies itself in its advance over the plain; so that the deposition must be greatest on the parts nearest to the margin of the river.

the Ganges is thus confined to the breadth of the Thames at Battersea for an extent of seventy miles; so that when the river is full, passengers look down on each side as from a lofty eminence into the subjacent country. During the swollen state of the river the tide loses totally its effect in counteracting the stream, and in a great measure its ebbing and flowing, except very near the sea. The following is a table of the gradual increase of the Ganges and its branches, according to observations made at Jellinghy and Dacca:—

| | At Jellinghy. Ft. | In. | At Dacca. Ft. | In. |
|---|---|---|---|---|
| In May it rose | 6 | 6 | 2 | 4 |
| June, | 9 | 6 | 4 | 6 |
| July, | 12 | 6 | 5 | 6 |
| The first half of August | 4 | 0 | 1 | 11 |
| | 32 | 6 | 14 | 3 |

These observations were made in a season when the waters were higher than usual; so that we may take 31 feet for the medium of increase. The inundation is at its height, and continues without diminution for some days before the middle of August, when it begins to run off; for although great quantities of rain fall in the flat countries during August and September, yet by a partial cessation of the rains in the mountains there happens a deficiency in the necessary supplies. The quantity of the daily decrease of the river is nearly in the following proportions:—During the latter half of August and all September, from three to four inches; from September to the end of November, it gradually lessens from three inches to an inch and 26 half; and from November to the latter end of April, the decrease is only half an inch per day at a medium. These proportions must be understood to relate to such parts of the river as are removed from the influence of the tides. The decrease of the inundation does not always keep pace with that of the river, by reason of the height of the banks; but after the beginning of October, when the rain has nearly ceased, what remains of the water is quickly evaporated, leaving

the lands highly manured, and in a state fit to receive the seed after the simple operation of ploughing.

The quantity of sediment contained in the water of the Ganges, according to Rennell, is truly astonishing. "A glass of water," he says," taken out of this river when at its height, yields about one part in four of mud. No wonder, then that the subsiding waters should quickly form a stratum of earth, or that the delta should encroach on the sea." Rennell also computed the mean quantity of water discharged into the sea by the Ganges through the whole year to be 80,000 cubic feet in a second. When the river is most swollen, and its velocity much accelerated, the quantity is 405,000 cubic feet in a second. Other writers agree that the violence of the tropical rains, and the fineness of the alluvial particles in the plains of Bengal, cause the waters of the Ganges to be charged with foreign matter to an extent wholly unequalled by any large European river during the greatest floods. The Ganges frequently sweeps down large islands, and Colebrooke relates examples of the rapid filling up of some branches of this river, and the excavation of new channels, where the number of square miles of soil removed, in a short time was truly astonishing, the column of earth being 114 feet high. Forty square miles, or 25,600 acres, are mentioned as having been carried away in one district in the course of a few years. If we compare the proportion of mud, as given by Rennell, with his computation of the quantity of water discharged, very striking results are obtained. If it were true that the Ganges in the flood season contained one part in four of mud, we should then be obliged to suppose that there passes down every four days, a quantity of mud equal in volume to the water which is discharged in the course of twenty-four hours. If the mud be assumed to be equal to one-half of the specific gravity of granite (it would, however, be more,) the weight of matter daily carried down in the flood-seasons would be equal to seventy-four times the weight of the Great Pyramid of Egypt. Even if it should be proved that the turbid waters of the Ganges contain one part in 100 of mud, which is affirmed to be

the case in regard to the Rhine, we should be brought to the extraordinary conclusion, that there passes down every two days into the Bay of Bengal a mass about equal in weight and bulk to the Great Pyramid.

The following table is given by Hamilton of the probable length of some of the rivers of India:—

| | Miles to the Sea. |
|---|---|
| 1. Indus | 1700 |
| 2. Jumna (to its junction with the Ganges, 780 miles) | 1500 |
| 3. Sutledge (to the Indus, 900) | 1400 |
| 4. Jhylum (ditto 750) | 1250 |
| 5. Gundock (to the Ganges, 450, | 980 |
| 6 Godavery, | 850 |
| 7. Krishna, | 700 |
| 8. Nerbudda, | 7[illegible] |
| 9. Mahanuddy | 550 |
| 10 Tuptee, | 460 |
| 11. Cavery, | 400 |

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## CATARACTS.

The Ganges, Indus, and Brahmapoutra, during their course amongst the mountains, exhibit cascades hitherto but imperfectly described. Some very splendid and beautiful waterfalls are met with in the Peninsula; the most considerable are those of Bundelcund, of the Western Ghauts, and of the River Cavery.

*Falls in Bundelcund.*—The only account we have met with of these magnificient falls is given by Captain Franklin. He visited all that are between the Katra pass and the Tones river. The first is near the village of Bilohi, about twelve miles west from the pass of Katra, where the fall of water is 398 feet, and the rocky wall of red sandstone over which it is precipitated nearly perpendicular. Ten miles farther west is the cataract of Bouti, 400 feet in height, which is very picturesque, owing to the great extent of the circus over which it falls. At Keuti, twenty-four miles farther west, is another fall 272 feet in height; and westward still, at Chachai, one 362 feet high. At a short distance from Chachai is the cataract of the Tonse, where the volume of water is

greater than in the others, but the fall less, being only 200 feet.

Many of the waterfalls in the Western Ghauts, although exhibiting magnificent scenes during the rains, are completely dried up in the hot season. There are many fine cascades in the Ghauts above Honoor, which for sublimity and magnitude will probably yield to few in the world. They have hitherto been little visited, even by Europeans in India; and it is, we believe, only within the last ten or twelve years that they have received a name. They are situated on the river Shervutty, about fifteen miles up the Ghauts from the town of Garsipa, and are now known to Europeans by the name of the Falls of Garsipa.

*Falls of Garsipa.*—The country in the neighbourhood of the falls, says Dr. Christie in a communication to us, is extremely beautiful, combining the majestic appearance of a tropical forest with the softer characters of an English park. Hill and dale are covered with soft green, which is finely contrasted with a border of dark forest, with numerous clumps of majestic trees, and thickets of acacias, the carunda, and other flowering shrubs.

Upon approaching the falls you emerge from a thick wood, and come suddenly upon the river, gliding gently among confused masses of rock. A few steps more, over huge blocks of granite bring you to the brink of a fearful chasm, rocky, bare, and black; down which you look to the depth of 1000 feet. Over its sides rush the different branches of the river, the largest stretching downwards without a break in one huge curling pillar of white foam. Beneath, the waters, by the force of their fall, are projected far out in straight lines; and at some distance below the falls form a thin cloud of white vapour, which rises high above the surrounding forest. The sides of the chasm are formed by slanting strata of rock, the regularity of which forms a striking contrast to the disorder of the tumultuous waters, the broken detached masses of stone, and the soft tint of the crowning woods.

The effect of all these objects rushing at once upon the sight is truly sublime. The spectator is generally

obliged to retire after the first view of them, in order gradually to familiarize himself with their appearance; for the feeling which he experiences in suddenly coming on them amounts almost to pain. After the first impression has somewhat subsided, and he has become accustomed to the scene, he can then leisurely analyze its parts, and become acquainted with the details.

The chasm is somewhat of an elliptical form. At its narrowest and deepest part is the principal fall; smaller branches of the river and little rills dash over its sides, and are almost all dissipated in spray before they reach the bottom. The principal branch of the river is much contracted in breadth before it reaches the brink of the precipice, where it probably does not exceed fifty or sixty feet; but it contains a very large body of water.

The falls can only be seen from above, for the cliffs on both sides of the river afford no path to admit of a descent. Some gentlemen had attempted to reach the bottom by having themselves lowered by ropes; but no one has hitherto succeeded.* A view of the falls from below, says Dr. Christie, would, I am convinced, exceed in grandeur every thing of the kind in the world. The spectator can very easily, and with great safety, look down into the chasm to its very bottom. Some large inclined plates of gneiss project from its edge; so that by laying himself flat upon one of these he can stretch his head considerably beyond the brink of the precipice.

Although no accurate measurement has yet been made of the height of these falls, it would appear from Dr. Christie's account, that they cannot be much short of 1000 feet.

*Falls of the Cavery.*—The falls in the course of the river Cavery, still farther south in the Peninsula than Garsipa, are celebrated by travellers. Of these two are particularly noticed, viz. the Ganga Chuki and Birra Chuki.

The branch of the river which forms the Ganga Chuki is subdivided into two lesser ramifications, a short distance above the fall. The nearest and by much the largest of these streams is broken by projecting masses

of rock into one cataract of prodigious volume and three or four smaller torrents. The water of the large cataract plunges into the ravine below, from a height of from 100 to 150 feet; while the smaller torrents, impeded in their course by the intervening rocks, work their way to a distance of about 200 feet from the base of the precipice, where the whole unite,—the other detached portion of the river precipitating itself at the same time in two columns from a cliff about 200 feet high, the rapid above flowing nearly at right angles with the principal branch. The surrounding scenery is wild, and the whole offers a most striking spectacle, especially during the height of the rains.

The second cataract is that of another arm of the Cavery, at a spot called Birra Chuki about a mile from the fall above described. The channel of the river here is spread out to a magnificent expanse, and its stream divided into no less than ten distinct torrents, which fall with infinite variety of form over a broken precipice of more than 100 feet, but presenting no single body of water equal in volume to the main fall at Ganga Chuki.

# CHAPTER III.

## GEOLOGY AND MINERALOGY.

Geology and Mineralogy—1. Soils of India, viz. Soil of Bengal; Cotton ground; Mosaree Soil; Laterite Soil; Nitre Soil; Soda Soil; Salt Soil—2. Geognostical Structure and Composition of India—1. Himmaleh or Alpine Region; Its Rocks, Minerals, and Mines—2. Middle India; Its Rocks, Minerals, and Mines—3. Peninsular India; Its Rocks, Minerals, and Mines—4. Submergence and Upraising of Land—5. Destruction of the ancient City of Ougein and other Places in India by a Shower of Volcanic Ashes—6. Earthquakes.

Regarding the geology and mineralogy of India our information is very defective, and many years must elapse before even the general geognostical and mineralogical relations of so vast a region can be determined. The India Company has munificently patronised the researches of the botanist; it is now time to encourage and forward other branches of science. We expect ere long to hear of the establishment of meteorological observatories amply furnished, in well selected stations, from Cape Comorin to the centre of the Himmalehs;—to find carried on by scientific men throughout India those important investigations requisite for the illustration of hydrography;—to rejoice in the appointment of active and experienced geologists, mineralogists, and zoologists, for every part of our Eastern empire.* What is known of the geology and mineralogy of India, has arisen from the labours of Hamilton, Buchanan, Heyne, Voysey, Dangerfield, Turnbull Christie, Franklin, Adam, Hardie, Webb, Herbert, Gerrard, Hodgson, Calder, Govan, and others. To such as have no opportunity of consulting the memoirs and works of these naturalists, the following short view of the geology of India may not be unprofitable.

* Dr. Turnbull Christie, we are happy to announce, has been appointed by the India Company to investigate the geology of the Bombay Presidency. A more fortunate selection could not have been made.

## I. SOILS OF INDIA.

The soil of India, as that of other countries, is formed principally by the action of the atmosphere on rocks, and dead animal and vegetable matter; the broken down or disintegrated rocks mixed in various proportions with decaying organic substances, giving rise to the different species of soil. These soils have paticular names in different parts of the country, and in many instances the distinctions are not without their practical utility. We connot attempt to give a detailed view of this subject, even were it required in a work of this description; what we consider necessary, we shall therefore include under the following heads:—1. Soil of Bengal. 2. Cotton ground or regur soil. 3. Musaree soil. 4. Nitre or saltpetre soil or ground. 5. Soda soil or ground. 6. Salt soil or ground.

1. *Soil of Bengal.*—There is no rock of any kind on the banks of the Hoogley, nor do we meet with any after entering on the principal stream on the Ganges, until we approach the province of Bahar. The whole country seems to consist of a mixture of clay and sand, in such proportions as to form a compound well adapted for the purposes of vegetation, and conducing, in no small degree, to that fertility for which the plains of Bengal are so celebrated. Disseminated scales of mica often give to this soil a glimmering appearance, and when mingled in minute grains with the sand, more or less prevalent on the banks of the river during its whole course, they impart a brilliant lustre to the extensive plains. Strata of sand of various colours are frequently observed lying over each other; these seem to have been formed in successive seasons; above them is a mixed soil, or sand approaching to soil. When not destitute of herbage the surface bears a coarse grass or reeds.

*On the Fertilizing Principle of the Inundations of the Hoogley.*—It is generally supposed that the fertilizing principle of the inundations of the great tropical rivers is vegetable matter in various states of decomposition.

The following details in regard to the *silt* of the Hoogley are at variance with that opinion. It is well known, says Mr. Piddington, that while the tracts within the reach of the inundation preserve their original fertility the higher soils are gradually and rapidly becoming impoverished, and this to a degree of which few, who have not made the subject one of attention, are aware; there are some crops which cannot be repeated, unless at intervals of three or four years; while on the lowlands these crops have been continued for a period beyond the memory of man. Indigo is a striking, and the most familiar instance of what is here advanced; the following analyses were made with a view to some improvement in the cultivation of that plant. Portions of the *silt* or *mud* deposited by inundations were procured from Bansbariah near Sukhsagar, and from Mohatpur near Kissinuggur; the analysis of each gave in two-hundred parts,—

| | Silt from Bansbariah. | Silt from Mohatpur. |
|---|---|---|
| Water, | 2 | 2 |
| Saline matter, principally muriate of potash, | 0¼ | 0½ |
| Vegetable matter destructible by heat, | 4¾ | 4½ |
| Carbonate of lime, | 12¼ | 16½ |
| Phosphate of lime, | 0 | 1 |
| Oxide of iron, | 12 | 12 |
| Silica, | 156 | 139 |
| Alumina, | 6½ | 14¾ |
| | 183¾ | 180¼ |
| Loss, | 16¼ | 9¾ |
| | 200 | 200 |

The unlooked-for circumstance of only two and a half per cent. of vegetable matter being found in these specimens, appeared almost to show that such matter was not the fertilizing principle, or at least not exclusively. On the other hand, from six to eight per cent. of calcareous matter appearing in them, when, in an extensive series of analyses of the higher soils, this was always found remarkably different (seldom more than 0.75 to 1 per cent.), it seemed probable that the calcareous matter was

the great agent; and in as far as regards indigo this was found by experiment to be the fact,—for a minute portion of lime was found to increase the produce upwards of 50 per cent. In considering this subject farther, it occurred to Mr. Piddington that lime might probably exist in solution amongst the rich mud on which the seed is sown as the waters retire,—and this was found to be the case; a quantity of it being procured at the moment of the subsidence of the waters, it was found that the drainings were highly impregnated with carbonic acid gas, and that lime was held in solution by it,—a fact which perhaps throws some light on the phenomena of the formation of *kunkur.*

2. The *Cotton Ground* or *Regur Soil* forms one of the most interesting features in the physical geography of many districts in India. It probably originates from the disintegration of trap rocks. It varies in depth from two or three to twenty or thirty feet, and even more; its extent is prodigious, as it covers all the great plains in the Deccan and Candeish, some of those in Hydrabad, and perhaps also those of other parts of India. This soil is as remarkable for its fertility as for its very great extent; and a curious circumstance is that, *it never lies fallow, and never receives the slightest manure.* Even the stems of the cotton-plant are not allowed to remain on it, being employed for making baskets, or used as firewood; moreover, in all those parts of the country where the cotton ground is met with, there is so little wood that cow-dung is carefully collected and dried for fuel. Cotton, javaree, wheat, and other grains, are raised from it in succession; and it has continued to afford the most abundant crops, without receiving any return for centuries, nay, perhaps, for 2000 or 3000 years,—thus proving the inaccuracy of the opinion held by agriculturists, that if something be not constantly added to land equal to what is taken from it, it must gradually deteriorate Attention must be paid to the order of cropping; but if the weather be favourable the ryot is always sure of an abundant harvest.

The fertility of this soil is probably owing in part to its

power of absorbing moisture from the atmosphere. This power is great, even when compared with the best soils in Britain. A well-known writer, Sir H. Davy, says, "I have compared the absorbent powers of many soils with respect to atmospheric moisture, and I have always found it greatest in the most fertile soils; so that it affords one method of judging of the productiveness of land." He farther states, that 1000 parts of a celebrated soil, from Ormiston in East Lothian, when dried to 212°, gained in an hour, by exposure to air saturated with moisture, at a temperature of 62°, 18 grains; and that 1000 parts of a very fertile soil, from the banks of the river Parret in Somersetshire, under the same circumstances, gained 16 grains. The following are the results of some experiments made by Dr. T. Christie on the absorbent powers of the cotton soil. He thoroughly dried a portion of the earth by a heat that was nearly sufficient to char paper. He then exposed to the atmosphere of a moderately damp apartment 2615.6 grains of it, and found, after a few days, that it had gained 147.1 grains. He now exposed it to an atmosphere saturated with moisture, and found that the weight increased daily till the end of a few weeks, when it was found to be 2828.4 grains. The soil had therefore gained 212.8 grains, or about 8 per cent.

In the hot season the *regur* or *cotton ground* is traversed in all directions by very deep fissures. In the rainy season it is in the form of very tenacious clay. Almost all the crops raised from it are sown towards the end of the rainy season, and therefore during their growth receive comparatively little moisture; often indeed none but that of the heavy dews descends on them for a length of time.

3. *Musaree Soil*—In many parts of India there is another soil, named the *mussub* or *mussaree soil*, which does not form extensive plains like the cotton ground, but is generally found at the foot of hills, or in the bottom of small valleys. At the bases of the sandstone hills it consists of little else than loose sand. On the sides of the hills that contain beds of quartz it is very gravelly.

4. *Laterite Soil.*—The *laterite* or brick stone affords in general, on disintegration, a soil not very productive, and apt to become extremely hard in dry weather; but in the bottom of many small valleys large deposites of it are met with, which have been more perfectly disintegrated and mixed with other substances, and form productive soils. The soils in the valleys of *clay-slate* districts are also in many places very good, when the clay happens to be mixed with fragments of quartz.

5. *Nitre or Saltpetre Ground or Soil.*—In India this soil is found in places where there has been a due admixture of animal and vegetable matter, as in old populous villages built on black cotton ground, or forming the rich mould of gardens, as in many parts of the Northern Circars. In such situations, from the beginning of the dry seasons in February till the rains commence again in May and June, the streets, and particularly the lower parts of the mud walls with which the houses are built or the yard surrounded, appear wet and black in the morning, and crumble down into a fine soft mould. What collects in a heap under the walls is gathered every other day by sweeping. It contains about one-fifth of its weight of crude saltpetre. The natives observe that this substance is produced abundantly in those years in which the preceding monsoon-rains have been strongest, and accompanied by a great deal of thunder and lightning. A heavy thunder-storm in April or May is likewise reckoned very favourable for the manufacture. When the saltpetre has been extracted from this earth, it is thrown in heaps, and spread out when the monsoon is over. After lying a year or two it is swept every day, and is again found to yield, by sweeping it every other day, saltpetre earth fit for the manufacture; for no potash is added, so that the saltpetre seems to be ready formed in the soil.

The manufacture of saltpetre hardly extends lower than the eastern limits of Bahar, and it is said that the production of nitre is greatest during the prevalence of the hot winds. These winds blow from the west, and formerly did not extend eastward beyond Bahar; but from

the change of seasons within these forty years their influence is now felt in Bengal; in which province, on that account, the extensive manufacture of saltpetre might be attempted with success.

Saltpetre grounds are frequent in Bengal. The tendency of the soil to reproduce saltpetre is very troublesome to the builders and the occupants of houses. "It can scarcely," says Heber, "be prevented from encroaching, in a few years, on the walls and floors of all lower rooms, so as to render them unwholesome, and eventually uninhabitable. Half the houses in Calcutta are in this predicament, and their ground-floors useless. Cellars are unknown in this part of India.

In Tirhoot, one of the principal districts in India for the manufacture of saltpetre, the soil, according to Tytler, is everywhere thoroughly impregnated with this substance. During the rains and cold weather, it appears abundantly on the lime on the walls of houses. From these and other damp spots it may be brushed off every two or three days almost in basketfuls. The ground too, even in the hot weather, is so moist that it is extremely difficult either to get earth of sufficient tenacity to make bricks (the country being quite destitute of stones,) or when the bricks are made to find a spot sufficiently solid to bear the weight of a house. Notwithstanding the greatest attention, the ground at length yields and the saltpetre corrodes the best of the bricks to such a degree that the whole house gradually sinks several inches below its original level. Houses built of inferior materials, of course, suffer much more; one, of which the inner foundations were of unburnt bricks, absolutely fell down whilst Dr. Tytler was at Mullye, and the family had a miraculous escape. Dr. Tytler's own house, one little better, sank so much, and the ground-work was so evidently giving way, that at great expense and inconvenience he was compelled to pull down the whole of the inner walls and rebuild them in a more secure manner. From the same cause a new magazine, which government had ordered to be built with an arched roof of brickwork, was, when complete, found so very unsafe that it was

necessary to demolish it entirely, and rebuild it on a new plan with a roof of tiles. One hundred parts of nitre earth or soil from the Tirhoot district, when analyzed by Dr. Davy, afforded,—

| | |
|---|---|
| Nitrate of potash,.............................. | 8.3 |
| Nitrate of lime,..... .............................. | 3.7 |
| Sulphate of lime,...... .............................. | 0.8 |
| Common Salt,..... .............................. | 0.2 |
| Carbonate of lime,..... ......................... | 35.0 |
| Earthy matter insoluble in water and nitric acid,.... | 40.0 |
| Water with a trace of vegetable matter,............ | 12.0 |
| | 100.0 |

The soil in many parts of Ajmere is very nitrous.

5. *Soda Soil or Ground.*—Soil more or less impregnated with carbonate of soda occurs in different parts of Mysore, where the soda is separated and used for glass-making and for washing. Soil of the same kind is found in the Coimbetoor province, and in many other parts of the Peninsula of India. Heyne says, the soda of the Mysore effloresces on a red ferruginous soil; when purest it is collected by the washermen, and used by them instead of soap; hence it is known by the name of washerman's earth. Soda also occurs in efflorescences on the surface of cotton ground; but there it is mixed with a great proportion of common salt, which forms the principal object of a manufactory carried on by the people called *tank-diggers* by Europeans, and *salt-people* by the natives. Saltworks of this kind are of frequent occurrence in the Mysore country, which renders importation of salt from the coast very trifling.

6. *Salt Soil or Ground.*—In many parts of India the soil is richly impregnated with common salt, thus forming a salt soil or ground, as it is sometimes termed. Thus, near to Vencataghery, common salt appears to be generally diffused over and through a black poor soil, where it is collected and used for culinary purposes. Between Baydamungulum and Tayculum in the Mysore, Buchanan had an opportunity of examining one of the places where salt is made. The situation was low and moist; the soil black mould, consisting of a mixture of sand and clay,

that from its appearance would have been reckoned good; but the impregnation of salt renders it for cultivation greatly inferior to soils apparently of a worse quality and free from salt. The natives allege, that if they walk much on this saline earth their bare feet become blistered. In the dry season the surface of the earth is scraped off and collected in heaps. In front of these heaps the native salt-makers construct a semi-circle of small round cisterns, each about three feet in diameter and a foot deep, with sides and floors of dry mud. Toward the heaps of saline earth there is in the floor of each a small aperture, with a wooden spout to convey the brine into an earthen pot placed in a cavity below. The floors of the cisterns are covered with straw and the saline earth is put in till it rises nearly to the level of the tops of the walls. On the surface of the saline earth water is then poured, which in filtering through into the pots carries with it all the salt. The inert earth being thrown out behind the cisterns is replaced with new earth for saturating more water. In the mean time the brine is emptied into a cavity cut in a rock, and is evaporated entirely by the sun. The natives say that the salt is sufficiently wholesome. The grain is large and consists of well-formed cubes; but the salt is mixed with much earthy impurity. It is principally used by the lower orders.

## II. GEOGNOSTICAL STRUCTURE AND COMPOSITION OF INDIA.

1. *Himmaleh or Alpine Region.*—It is said that the principal *valleys* in this Alpine land are perpendicular to its direction, that is, run from north-north-east and north-east to south-south-west and south-west; and that frequently the surface exposed to the west is rugged, while the opposite one, facing the south-east, is shelving. The *forms of the mountains* are exceedingly varied, being described as needle-shaped, peaked, conical, ridge-shaped, and round-backed. There are *precipices* often of fearful abruptness and magnitude, sometimes continuing mural

or perpendicular for miles, with an elevation of 200 and 300 feet; and, according to some travellers, even of 2000 and 3000 feet. The *passes* that lead through this extraordinary region vary in height, from that of Tungrang, one of the lower passes, which is 13,740 feet, to the pass of Charang, 17,348 feet above the sea. We possess but little information as to the general and particular direction and dip of the strata; even the principal geognostical features of the various formations are scarcely at all known to us.

1. *Primitive Rocks.*—From the reports of Webb, Gerrard, Franklin, Govan, and Colebroke, it appears that *gneiss* is one of the most abundant of the stratified primitive rocks; associated with it, in some places having a subordinate character in others predominating, there occur *mica-slate*, *clay-slate*, *quartz-rock*, *hornblende-rock*, *potstone*, *indurated talc*, *primitive-limestone*, and *gypsum*. These rocks are variously intersected by *granite* and *quartz veins*, and in some quarters vast bodies of *granite* forming whole mountains, are observed rising through the stratified Neptunean rocks above enumerated. Schorl and tourmaline are of frequent occurrence in these rocks. Of the gems, the precious garnet is the only one we have seen in specimens from the Himmalehs, nor is any other mentioned by travellers. It has been found in granite at the enormous height of 22,000 feet above the sea,—an interesting fact, showing that the garnet is found at a greater elevation than any other gem. The observations of our pupils in tropical regions, and at the highest northern latitude hitherto reached by man, likewise show that this beautiful precious stone ranges from the equator to the vicinity of the north pole. The following is an enumeration of the heights above the sea at which several of the primitive rock-formations have been noticed:—

| | Feet. |
|---|---|
| A cavern in primitive limestone near the Sutledge,......... | 6500 |
| Mountain near the Sutledge, composed of gneiss,.......... | 8350 |
| Eastward of the Tarhegang mountain, at the head of the rivulet Ripsang, the rocks are gneiss, granite, mica-slate, and quartz-rock, with tourmaline,.. ...................... | 11,000 |

| | Feet. |
|---|---|
| Pass of Bruang, mica-slate, gneiss, granite, containing tourmaline and garnet, | 15,000 |
| The Rollor or Shatul pass, gneiss, | 15,000 |
| Mountains near to the Shatul pass, mica-slate, gneiss, and granite, | 15,556 |

2. *Transition Rocks.*—On the primitive formations rests a vast deposite of rocks of the transition class, principally consisting of *clay-slate, graywacke-slate, graywacke flinty-slate, gypsum and transition-limestone.* Fossil organic remains first appear among these deposites. The *ammonite* is the most celebrated, on account of the superstitious value attached to it. The heights stated under are probably formed of transition clay-slate, and therefore belong to this section:—

| | Feet above the Sea. |
|---|---|
| Overhanging the town of Marang, a mountain of clay-slate, | 12,000 |
| Tungrang pass, clay-slate, with pyrites and mica, | 13,740 |
| Mountains of clay-slate on the Chinese frontier, containing ammonites, | 16,200 |
| Mountains in the neighbourhood of Charang, of blue clay-slate, | 18,000 |

*Mineral Substances useful in the Arts found in the Primitive and Transition Rocks of the Himmalehs.*—We shall notice the rocks and minerals in the following order:—1. Rocks. 2. Saline minerals. 3. Inflammation minerals. 4. Metallic minerals.

1. *Rocks.*—*Granite.*—Many fine granites occur in the Himmalehs, which, owing to their remote localities, are as yet of but little value. A beautiful gray porphyritic granite occurs, however, close to the cantonment of Almora, which would furnish ornamental pillars or slabs of any size.

*Clay-slate.*—Of this rock, so useful as a roofing material, many extensive deposites are known, but hitherto they have not been quarried.

*Limestone.*—Under this name we include the various marbles, whether white or coloured, they have been seen in the valleys and mountains. Captain Franklin mentions a variety resembling that of Iona, found at no great distance from the plains, and also a fine dolomite marble

which he observed in many places. At no great distance from the Iona-like marble there is a flesh-coloured dolomite, with purple-clouded delineations, which promises well. A marble of more crystaline nature appears on the road to Bhadreenath above the Bishen Ganga.

*Gypsum.*—This rock has a pure white colour and granular foliated structure. "It is probable," Captain Franklin remarks, "that its chief use in Bengal, for some time, would be as convertible into plaster of Paris, and affording a material for cornices and ornamental work, to the banishment of the very rude productions of this kind we have hitherto put up with. There is, perhaps, a sufficient quantity of it to answer any demand likely immediately to arise. When the government-house was last repaired, it was considered desirable to obtain a sufficiency for the purpose above indicated; but the fact of its occurrence within our mountain-provinces was not known at that time. As it is within fifty or sixty miles of water-carriage, it might be expected to pay for its transport."

*Potstone.*—This rock may be used with advantage for lining ovens and furnaces, and for architectural purposes. From its softness, it might easily be turned on a lathe into various useful articles.

2. *Saline Minerals.*—*Alum.*—This saline mineral occours in efflorescence on rocks of different kinds, particularly on alum-slate, and might in some situations be collected with profit.

*Sulphate of Iron or Green Vitriol.*—This salt too is met with frequently as an efflorescence, on rocks containing pyrites or sulphuret of iron. We do not know that it is any where collected for economical purposes.

*Borax.*—Although this salt has not been discovered within the present limits of British India, still, as the production of a neighbouring country and a valuable article of commerce, it may be mentioned. The whole supply of the Eurpean market passes through these mountains.

3. *Inflammable Minerals.*—*Sulphur.*—Depositions of sulphur are formed around hot springs, in the bed of the

Ramganga and of the Garjia rivers, in the province of Kemaoon, but mixed with carbonate of lime, from which it can be readily separated by sublimation. It occurs in considerable quantities in some of the galleries of the lead-mines at Mywar on the Tonse, in Jaunsar.

*Mineral Oil and Pitch.*—These minerals do not occur any where abundantly. Mineral oil is mentioned as having been observed oozing from rocks of limestone in the range between Sarju and the Ramganga.

*Graphite, or Black Lead.*—This valuable mineral has not hitherto been found in considerable quantity in any part of the Himmalehs, although, from the nature of the country and the notices of travellers, it is not improbable that enough of it will be met with for the various purposes of the arts. It occurs in embedded masses, varying in size from an inch to three or four inches in diameter, in a graphitic mica-slate.

4. *Metallic Minerals.*—The Himmalehs have hitherto afforded but a comparitively small quantity of ore, owing not so much to the poverty of this vast country in metalliferous substances as to the neglect of observers, who have been principally occupied with geographical investigations and the collecting of plants. The only metals at present met with in such quantity as to yield a profitable return are, copper, iron, and lead; but besides these there also occur gold, antimony in the state of sulphuret, the gray antimony ore of mineralogists, and manganese combined with iron. We shall now notice in a general way these different substances.*

*Gold.*—In the Old World, almost every extensive range of mountainous country has been found to afford gold, which is indicated either by its occurrence in the sands of rivers and rivulets, or disseminated in diluvia, or through the mass of solid strata. The gold of the Himmalehs occurs in the alluvial soil of several mountain-rivers, and one instance is mentioned of its having been observed in grains in granite at Kedarnath. During

* Arsenic combined with sulphur, or in the state of yellow and red orpiment, is imported from beyond the frontiers, for it has not been found in the British dominions.

the Gorkhali rule, the gold collected afforded a small duty; but the amount was too trifling to render its continuance expedient. It is collected from loams, sands, and clays, by washing in the usual manner.

*Copper Mines.*—There are seven places where ores of copper are raised; these are,—

| | Rupees per anuum as rent. |
|---|---|
| 1. Dhanpur, 2. Dhobri, | 1200 |
| 3. Gangoli, 4. Sira. | 1000 |
| 5. Pokri, | 600 |
| 6. Khari, | 40 |
| 7. Shor Gurang, | 50 |

These mines, if they deserve the name are worked in the most miserable manner, under every disadvantage, and therefore afford but paltry returns. No mine can thrive in our Indian possessions until well-instructed mine-masters and experienced miners are sent out from Europe.

The ore found in the Dhanpur mine is *gray copper ore*, which affords from 30 to 50 per cent. of copper; it is associated with *malachite*, or green carbonate of copper. The ores are contained in a compact red-coloured dolomite; hence mining operations can be carried on without the expense of wooden frame-work or masonry. The Pokri mine or mines are situated in talc slate of a loose texture; and hence the working is more difficult. The ores are *vitreous* and *purple copper*, both of them rich in copper. The waters flowing from the mine are impregnated with *sulphate of copper* or blue vitriol. The Sira and Gangoli mines are situated in beds of indurated talc, which are enclosed in dolomite. Sometimes the one, sometimes the other rock, form the walls and roof of the mine. The iron is *yellow copper or copper pyrites*, mixed with iron pyrites and smaller portions of gray copper ore. The Khari and Shor Gurang mine are similarly situated, the ores are *gray copper*, *yellow copper* or *copper pyrites* and *carbonate of copper*. The method of working these mines is as follows:—A gallery or passage is cut

into the face of the hill, with such a bottom declivity as to allow the water to run off. Where the rock may require it, frames of timber rudely constructed are set up to support the roof and sides. The area of the gallery is always small; in those parts where the hardness of the rock occasions any difficulty in working, it is scarcely sufficient to admit a person even in a creeping posture. In no place will it admit of an erect position. The ore is detached by means of a very ill-shaped and disproportioned pick, and by chisels and hammers. It is removed from the mines on skins, drawn along the floor of the gallery by boys. The ore, being delivered at the mouth of the mine, is reduced to small fragments by the hand. At Dhanpur, however, the work is done by a water-mill. It is next roasted in an open fire or forge-hearth with charcoal, and the heat occasionally urged by means of two air-bags or skins, which are alternately shut and opened by the hand. After being in this way imperfectly roasted, it is smelted on the forge-hearth, and the process is repeated till the metal is sufficiently pure. No flux appears to be used to assist the operation.

*Iron Mines.*—The wretched condition of Indian mining is shown by the fact, that the united rent of the numerous iron-mines does not exceed the annual sum of 1500 rupees, while the iron is of the very worst quality. The mining and metallurgical operations in use are on a parallel with those of Europe during the dark ages. The Himmaleh mines supply chiefly varieties of *red iron ore*, affording from 60 to 30 per cent. of metal. *Red hematite*, associated with micaceous iron ore, occurs in a large bed in gneiss at Dhaniakot on the Cosillah. At Ramghur, on the road from Bhamaori to Almora, there are beds of the scaly red iron ore also in gneiss. *Compact red iron ore* occurs in clay-slate, containing beds of limestone, at Katsari on the Ramganga. The iron manufactured from it is esteemed the best in the province of Kemaoon. Near Kalsi, on the Jumna, there is an extensive bed of *specular iron ore*. In Chawgarka-purgunnah the ore is the *brown* or the hydrated species, which contains manganese; hence the superiority of the steel prepared from it.

*Lead Mines.*—Of these mines, which are numerous, the most productive are situated on the river Tonse, at no great distance from the Deyra Dhoon. The Borela mine in this district formerly paid 2000, the Maijar 4000 rupees yearly; but the present rents are much lower. The ore, which is fine granular galena, is found in clay-slate and clay-slate limestone.

5. *Secondary Rocks.*—Resting upon the preceding primitive and transition rocks, but occupying a much lower situation, we find formations of the secondary class. These form the immediate north-east boundary of the great alluvial plain of Middle India, and are principally of sandstone, in all probability of different ages.

Mr. Scott has communicated, through Mr. Colebrooke, some details in regard to the secondary strata he observed on the banks of the Tista and Subuck, where they issue from the mountains of Bootan. The strata he noticed on the Tista are micaceous sandstone, bituminous shale, slate-clay, and *coal;* and rocks of the same description were observed on the Subuck. The coal has a dark *brown colour*, with a conchoidal fracture, and is associated with fossil wood. The colour of the coal would seem to intimate that it belongs to the brown coal series, and therefore is of a more recent origin than the coal of Damoda near to Calcutta. The hills formed of these strata, in Mr. Colebrooke's opinion, may be considered as fair examples of the entire range which skirts the north of Indostan. They rise to no great height, and constitute the first step from the plain of India, ascending towards the mountains of Bootan and the loftier peaks of the Himmalehs. Every where, so far as is yet ascertained, the lower range of hills consists of sandstone abounding in mica. To the above details we may add, that throughout the whole line of sandstone hills that lie at the foot of the Himmaleh chain, according to Captain Herbert, coal occurs in beds varying from a quarter of an inch to a foot in thickness. It often shows the ligneous texture; and where that texture is no longer visible it presents a conchoidal fracture, and burns with much flame and smoke. It appears to be the brown coal of Werner.

6. *Tertiary Rocks.*—An interesting display of rocks of this class was discovered by Mr. Scott at Cooch-Behar on the north-east border of Bengal, where the Brahmapoutra emerges into the plain. The strata are of yellow and green sand, alternating with clay, that lie horizontally at the height of about 150 feet above the level of the sea, and contain organic remains resembling those of the blue clay of the London and Hampshire basins. Mr. Scott also noticed, at Robagiri in the same district, a stratum of white limestone containing nummulites and vertebræ of fish surmounted by beds of clay which contain the same nummelities, and also bones of fish, with specimens of the genera *Ostrea* and *Pecten.* Near Silhet, the Laour Hills composed of white limestone abounding in nummulites, form another example of a tertiary formation in the eastern extremity of this province. Mr. Pentland discovered among mutilated fragments of bones, referable to the mammalia from these tertiary deposites, remains of four distinct species, viz., 1. A new species of the genus *Anthracotherium* of Cuvier; 2. A small species of ruminant allied to the musk-deer tribe; 3. A small species of herbivorous animal referable to the order Pachydermata, but more diminutive than any of the fossil or living species; and 4. A carnivorous animal of the genus weasel or viverra. In addition to the above, the following are mentioned by Mr. Colebrooke:—Sharks' teeth, vertebra and fin-bone of a shark, crocodiles' teeth, vertebra of a crocodile's neck, thigh-bone of a crocodile, dorsal fin and pectoral fin of a balistes, palates of the ray, palates of the diodon, oyster-shells of various species, a *Turritella,* and several species of *Balani* and *Patellæ.* These strata thus present us with the same association of organized remains that accompanies the tertiary strata of Europe, in which extinct genera of the Pachydermata have been discovered, and also with marine shells of the same genera, if not the same species, with those which characterize the most modern antediluvian formations, those described under the title of upper marine formation in the Paris basin, and to which are to be referred the extensive marine

deposites encircling the shores of the Mediterranean, those covering the less elevated countries of Central Europe, and that appear to extend as far as Lake Ural into the interior of Asia. The tertiary deposites of Caribari, as already noticed, appear to form a band at the base of the Thibetian mountains, since we find them extending to Silhet. How far this formation may stretch along the Peninsula of Malacca and Indostan it is impossible at present to say; although it seems to occur at Madras, where it contains the same shells as on the Brahmapoutra, and at Pondicherry, where it encloses great masses of woodstone.

7. *Alluvial Rocks.*—The usual alluvia deposites occur throughout the Himmalehs. The most curious statement in regard to them is one made by Gerrard, who tells us that he met with fossil shells in alluvium at a great height among the mountains, as fresh and entire as if they had recently emerged from their own element; and that, just before crossing the boundary of Ladak and Bussahir, he was much gratified by the discovery of a bed of antediluvian oysters clinging to the rock as if they had been alive, and this at 16,000 feet above the sea. The verification of this observation is expected.

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## II. MIDDLE INDIA.

In this vast tract the country forms an inclined plane, of which the great declivity sinks gradually towards the mouth of the Ganges, while the other inclines towards the Indus. It is almost entirely composed of alluvial clays, loams, sands, and gravels, with occasional intermixtures of calcareous concretions named *kunkur*, fossil woods, and animal remains. The most remarkable deposite of the latter was discovered near Pinjore, north latitude 30° 47′, east longitude 76° 54′, during the digging of a canal between two rivers, by the Sultan Ferose III. It was observed on cutting through a hill, in which bones of elephants and men were found. The bones of the fore-arm measured 3 gez, or 5 feet 2 inches in length;

hence it is evident that none of them were human, but belonged to large Pachydermata; but whether elephant or mastodon is not so apparent. The few fixed rocks that occur during the course of the Ganges are to be viewed as prolongations of the primitive and secondary rocks of the peninsular part of India. We may however, include in this division of India the *coal-field* of the Damoda. This deposite of coal, which occupies both sides of the river, has been traced southward to within a few miles of Raghunathpur, reposing on granite and syenite; and about forty miles north by east from that place we come to the first colliery ever opened in India. The late Mr. Jones, who had the merit of commencing these works in 1815, describes this as the north-west coal district of Bengal; he states that he observed the line of bearing for sixty-five miles in one direction, its breadth towards Buncora (on the south-west side) being not more than eleven or twelve miles from the river; and he conjectures, although erroneously, that the same coal-formation, crossing the Valley of the Ganges near Catroa, unites with that of Silhet and Cashar, which he denominates the north-east coal district. The rocks of this coal-formation are sandstone, slate-clay, bituminous shale, and coal, traversed by veins of *green stone*. The bituminous shale, of the coal-roof abounds with vegetable impressions, and also contains some animal remains. The vegetables have not been accurately examined, which is much to be regretted, as it would be highly interesting to know if the same or different genera or species occur in the coal-field of Bengal as those met with in similar geognostical situations in Europe. Mention is made of a *Calamite*, a *Lycopodum*, and a gigantic species of *Patella*. In the coal-pits, of which there are but three, sunk to a depth of ninety feet, there are seven beds of coal; one of them exceeds nine feet in thickness. The coal is said to resemble that of Sunderland in England, but leaves a larger portion of cinders and ashes. It is now extensively consumed in and about Calcutta.

## III.—PENINSULAR INDIA.

A very large portion of the Peninsula of India is composed of Plutonian rocks, as of granite, and trap, the Neptunean strata being much less abundantly distributed. We shall now state in a general way what is known of the geognostical nature of these formations, following in our sketch a geographic order.

Guzerat is a primitive district, with occasional displays of secondary deposites, and in many places deeply covered with diluvium. In the neighbouring district of Cutch, so remarkable for its salt marsh called the Runn, a *coal-field* is said to have been discovered, and is likely to be worked. Our former pupil, Mr. Hardie, who has made so many good observations, informed Mr. Calder, that, from specimens he had received, he was led to believe that in Cutch there existed secondary rocks newer than the lias. We hope Mr. Hardie will be able to verify these conjectures, which are not without probability, when we call to recollection the chalky minerals met with in the great Western Desert of India.

The great western or Malabar chain of mountains, which commences in Candeish and terminates at Cape Comorin, is at its northern extremity covered by a part of the extensive *overlying trap-formation*, which extends in this quarter from the sea-shore of the Northern Concan to a considerable distance eastward, above and beyond the Ghauts, as far as the river Toombuddra and Nagpore. The rocks of this formation, which are greenstone, basalt, amygdaloid, wacke, and trap-tufa, are columnar, globular, tabular, and amorphus. The amygdaloidal structure is most general in the cavities of which rock, amethyst and various beautiful and splendid zeolites occur. The trap hills are tabular, terraced, separated from each other by ravines often of vast magnitude, and the whole frequently covered with fine forests of teak and other trees, forming some of the most romantic scenes in India. The elevation of this part of the range

seldom exceeds 3000 feet; but advancing towards the south its height gradually increases, and granite rocks begin to appear above the surface between the seventeenth and eighteenth degrees of north latitude, and from thence forming, along with gneiss and other Neptunean primitive strata, the chain, with little interruption, all the way to Cape Comorin, and thence to the extremity of the Peninsula. The granite tracts of India exhibit the same general forms as granitic countries in other parts of the world. Rugged hills, with bold denticulated outlines, lie grouped together in the greatest irregularity, or occasionally form ridges, which when interposed between the spectator and the evening or morning sun, present the most varied and fantastic forms. Some of these ridges, when their dark outline is seen at twilight against a ruddy western sky, emulate in their various forms the apparently capricious forms of summer clouds, and we can then trace along their summits the appearances of castles, trees, men, and various strange groups. Many of the hills have the appearance of mere collections of large fragments of rock thrown confusedly together by some convulsion of nature; while frequently larger masses, piled with great regularity on each other, look like remains of gigantic architecture. High insulated masses, forming considerable hills, in many instances rise abruptly out of a plain to a height of several hundred feet, and present nearly mural faces on several of their sides; thus affording situations of immense natural strength, which have almost invariably been taken advantage of by the natives for the erection of their famous *hill-forts.* These insulated hills are generally met with at the borders of the granite district, when it is succeeded by the stratified, primitive, or transition rocks; and being situated in the midst of very extensive plains, when they are seen at some distance, they have very much the appearance of rocky islands in the midst of the ocean. Some of the strongest hill-forts in India are of this description; for instance Chittledroog, Gooty, Copaldroog, Eidghur, &c. Granite and syenite are traversed by two kinds of trap; the one is contemporaneons horblende, the other

secondary greenstone. In nearly the same parallel of latitude, this trap formation is observed to terminate also on the sea coast a little to the north of Fort Victoria or Bankot, where it is succeeded by the *laterite*, which extends thence as an overlying rock, with little interruption, to the extremity of the Peninsula, covering the base of the mountains, sometimes also their summits, and the whole narrow belt of land that separates them from the sea; exhibiting a succession of low rounded hills and elevations, and resting on the primitive rocks, which sometimes rise above the surface; as at Malwan, Calicut, and some other points, where granite, for a short space, become the surface rock. From the mainland the laterite passes over to Ceylon, where it reappears under the name of *kabuk*, and forms a similar deposite of some extent on the shores of the island.

From the extreme point of the land, on the eastern side of the Peninsula and northward along the foot of the mountains, we meet with a country differing considerably from the Malabar coast in aspect and geognostical structure and composition. The plains of the Coromandel coast form a broad although unequal belt of land between the mountains and the sea, composed partly of river partly of sea alluvium. The mountain chain that forms the eastern boundary of the Peninsula begins to diverge eastward, where its continuity is interrupted by the Valley of Coimbetoor. Thence it divides into many chains, parallel to the great western range, but of inferior height; and in the farther progress northward, after branching off into subordinate hilly groups, occupying a wide tract of almost unknown country, and affording valleys for the passage of the great rivers that drain nearly all the waters of the Peninsula into the Bay of Bengal; this eastern range may be said to terminate at the same latitude as that of the commencement of the western. Granite and syenite appear to form the basis of the whole of these eastern ranges, appearing at most of the accessible summits from Cape Comorin to Hydrabad. Resting upon them are various primitive and transition stratified rocks, as gneiss, mica-slate, quartz-rock, clay-

slate, chlorite-slate, talc-slate, potstone, serpentine, gray-wacke, and limestone. In many places there are extensive deposites of a red sandstone, and also some partial displays of overlying trap.

The flat country of the Carnatic, that is of the country east of the Ghauts of Mysore as far as the Pennar river, seems to consist of the debris of granitic rocks, with plains of sand and mud, probably left by the retreating sea. In confirmation of the former presence of the sea in the tract now occupied by the flat lands, the following fact may be mentioned:—On digging a garden about two miles from the sea shore at Madras, from the surface, for five feet, there was a stratum of brown clay, chiefly intermixed with sand; then followed a stratum of bluish-black clay, in which, at the depth of twenty-one feet, was a thin and scattered layer of large *oyster-shells*, all lying in a horizontal position; into the lamina composing the shell the black clay had penetrated, so that they split asunder with great facility. There were also shells of the cockle and other kinds. At the depth of twenty-seven feet springs began to gush, the stratum became softer, and more and more mixed with quartz-sand, still, however, of a dark slate colour. This continued to the depth of thirty-seven feet. In the neighbourhood of Pondicherry are beds of compact shelly limestone, and some remarkable silicious petrifactions, said to be chiefly of the tamarind-tree. These deposites at Madras and Pondicherry are considered to be tertiary. The bed of the Cavery, or rather the alluvial deposites in the vicinity of Trichinopoly, afford *gems* corresponding to those found in Ceylon In approaching the Pennar, the laterite formation expands over a larger surface, and clay-slate and sandstone begin to appear. The river-districts of the Pennar, Krishna, and Godavery, are based on granite, syenite, and various primitive stratified rocks, all of which are frequently traversed by veins and overlaid with masses of trap. Upon the primitive rocks rest sandstone, and a limestone resembling in some of its characters the *lias* of England. The well-known diamond-mines of this part of the Peninsula are situated in the

sandstone districts of these rivers. The Krishna is much richer in gems than the Godavery, or probably than any other river of Indostan. The waters of the Krishna and Godavery as they approach the sea divide into numerous branches, and deposite their mineral contents during inundations over the low level tract that separates them. These deposites consist, according to Heyne, of a black earth, composed of the debris of trap rocks, and of decayed vegetable matter washed from the extensive forests through which these rivers flow. A characteristic difference may be pointed out in regard to the alluvium of the principal river of the south,—the Cavery. This river, flowing in a long course through the Mysore country, over an extensive and generally barren surface of granitic rocks, with scarcely any woods or jungle on its banks, seems to bring down little or no vegetable matter, but a rich clay, produced from the felspar which predominates in the granites of the south, intermixed with decomposed calcareous conglomerate, rendering the plains of Tanjore the most fertile portion of the south of India. Onwards to Vizagapatan and Ganjam, syenite and gneiss predominates, and are occasionally covered with laterite. The granite and syenite at Vizagapatan contain numerous embedded garnets. This variety of granite passes into the province of Cuttack. Granite and syenite, with their usual accompanying stratified primitive rocks, form the basis and principal elevations of this district. Sandstone extends over a great part of the district of Cudapah: it is in this sandstone, or amidst its debris, that some geologists place the original repository of the diamonds found in this part of India. Coal is reported to occur here, and the sand and loam of the Mahanuddy, besides diamonds, affords grains of gold. Granite and gneiss, covered more or less completely with sandstone and laterite, continue onward through the district of Medinpur, and thence northward by Bishenpur and Bancora to Birbhum. At Bancora the calcareous rock named *kunkur* begins to cover the surface of the granite and syenite rocks, which rise above the surface to considerable elevations.

In our progress onward we pass the coal-field of Damoda, already described; and from it, in a north-westerly direction, the road to Benares leads over granite, of which the ranges of hills on the left, and the whole country as far as the Soane, and round by Shirghati and Gaya, is probably composed. On approaching the Soane river, and crossing the hills behind Sasseram, *sandstone* begins to appear, and seems to continue, with probably only one considerable interval, all the way to Agra, forming, as already mentioned, the southern boundary of the Ganges and Jumna; that interval occurs in the low land of Bundelcund, where the remarkable isolated hills, forming ridges running south-west and north-east, are all granite and syenite, the high lands being covered with sandstone. The geognosy of the Vyndhia mountains, which cross the Peninsula from east to west, uniting in some degree the two northern extremites of the Malabar and Coromandel ranges, has been partially examined. It can be traced ranging about 75° west, from the point called the Ramghur hills, towards Guzerat. The predominating rocks in this vast space are granite and syenite, with gneiss, mica-slate, quartz-rock, clay-slate, graywacke, and other primitive and transition stratified rocks, the relations of which may be well studied in the Oodipoor primitive chain of this range, also on the verge of the trap near Jabulpur, and in the bed of the Nerbudda at Beragerh, near Garrah. These rocks are more or less extensively covered by secondary sandstones and limestones, of the coal, new red sandstone, and lias formations, and traversed and overlaid by enormous bodies of trap. The extent of the trap-rocks is very great; for it has been traced northward all over Malwah and Sagar, and eastward towards Sohaghur and Amerakantak; thence extending southward by Nagpore, it sweeps the western confines of Hydrabad, nearly to the fifteenth degree of latitude, and bending to the north-west, reaches the sea near Fort Victoria (including the islands of Bombay, Salsette, and Elephanta), and forms the shores of Concan northward, all the way to the mouth of the Nerbudda, covering an area of upwards of

200,000 square miles. This vast igneous formation covers sandstone in the district of Sagar, and comes also in contact with limestone, which it converts into dolomite. This sandstone, which is red, and generally horizontally stratified, is associated with red marl, and is sometimes saliferous; hence it is considered to be identical with the *new red sandstone* of Europe. The limestone rests upon the sandstone, and is referred to the *lias formation* of England. The well-known diamond-mines of Pannah occur in this sandstone. The sandstone flanks the great range of primitive and transition rocks, which extends from Guzerat by Oodipoor; to the north it stretches into the Desert to an unknown extent.

Peninsular India, like every other part of the globe, is more or less covered with layers of alluvial matter of various qualities and ages; but hitherto neither in Peninsular, Middle, nor Alpine India, have active or extinct volcanoes been met with, if we except the volcano said to have burst forth thirty miles from Bhooj during the earthquake of June 1819.

India, as appears from the preceding details, affords examples of most of the rocks of the primitive and transition classes; but of the secondary series, the only formations hitherto discovered are the old red sandstone, coal formation, new red sandstone, and lias, the upper secondary deposite, as oolite, green sand, and chalk, being awanting. Small deposites of terteary strata occur in the north-east of Bengal, and the littoral deposites on the plains of the Coromandel coast are probably referable to the same class. The age of the Himmaleh chain is at present unknown, and we are also ignorant of the period or periods when the ranges of Peninsular India were elevated. These periods can be determined only after an examination of the phenomena exhibited at the line of junction of the ranges with the bounding strata. Thus, for example, if any range is found to have upraised the new red soandstone strata, but not the lias limestones which remain in a horizontal position, we infer that the range has risen through the new red sandstone before the deposition of the lias, and

therefore that it is newer than the new red sandstone, but older than the lias.

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## MINERAL SUBSTANCES USEFUL IN THE ARTS FOUND IN MIDDLE AND PENINSULAR INDIA.

1. Rocks—2. Earthy Minerals—3. Saline Minerals—4. Inflammable Minerals—5. Metallic Minerals.

### 1. ROCKS.

1. *Granite and Syenite.*—These rocks, which extend with few interruptions from Cape Comorin to beyond Nagpore and Ellichpore, occupying a great part of the Carnatic, Malabar, and Mysore, nearly the whole of the Nizam's dominions, and a large part of Bahar, and which are met with still farther to the north,—in Malwah, Bundelcund, the neighbourhood of Delhi, and, as already mentioned, even high among the Himmalehs,—are interesting in an economical view. Granite is not generally employed in India as a building stone, on account of the great expense in working it; but large slabs are sometimes brought into the bazars for sale by the Wudrahs (a vagrant class of people, somewhat resembling gipsies), and are used for paving the floors of verandas in the better sort of native houses, and other similar purposes. It is also hewn into hand-mills for grinding corn; two or four of which load an ass or bullock, and are thus carried to the bazar for sale. These are the primeval mills of all countries, from the North Cape of Europe to Cape Comorin, and are the same as are mentioned in Scripture. The ancient Hindoo temples at Anagoondy, now partly in ruins, are built of gray granite, or rather syenite. The massive and gloomy style of architecture which characterizes all Hindoo buildings, is also met with here; but in one instance it has to a certain degree been departed from, for in one of the principal buildings there is an extensive colonnade, the columns of which are light, with small pedestals and capitals, and approaching somewhat in their proportions to the Grecian. Some of the pillars

are tastefully carved with flowers. A few are in the form of caryatides. They support immense slabs of granite, which are carved on their under surface, so as to form an ornamental roof. The largest of these slabs, which are in the central part of the building, are at least thirty feet long. A black-colored trap, which occurs embedded in the syenite and otherwise associated with it, is extensively used in India for architectural purposes, and for statuary.

The Hindoos polish all kinds of stones by means of pounded corundum mixed with melted lac. The mixture being allowed to cool, is shaped into oblong pieces three or four inches long. The stone is sprinkled with water, and at the same time rubbed with these oblong masses and the polish is increased by the use of masses with successively finer grains.

*Talc-slate and Potstone.*—These minerals frequently occur together associated with various transition rocks. Potstone is found along with talc-slate and chlorite-slate in the south-east part of the Darwar district, and is used by the natives in the manufacture of various utensils. It is so soft, that pencils are formed of it for writing upon books made of cloth blackened and stiffened with gum. Both the books and the neatness of the writing are very inferior to similar ones of the people of Ava. All the fine plaster, so much admired by strangers with which the walls of the houses are covered in India, is composed of a mixture of fine lime and soap-stone rubbed down with water. When the plaster is nearly dry, it is rubbed over with a dry piece of soap-stone, which gives it a lustre very much resembling that of well-polished marble.

*Limestone.*—Some hills on the north and north-east of Guzerat are said to be chiefly composed of marble, exhibiting many colours and qualities. The coarse granular white, and white with black veins, are the most frequent; but among the ruined tombs and *murjids*, in the neighbourhood of Ahmedabad, may be found many small granular varieties of different colours, as white, yellow with red veins, and green clouded with yellow and even black. Of these deposites of marble no account has been published. A variety of limestone met with near

Bagulkote, in Darwar, answers well as a lithographic stone; for which purpose it has been used at Bombay. Lucullite marble is mentioned by Dangerfield among the productions of Malwah, and Tod says there are marble quarries in Rajast'han. The *kunkur*, a calcareous deposite, is used for cement and as a manure.

*Laterite* or *Ferruginous Clay-stone.*—This mineral may be described as a clay-stone, more or less impregnated with iron, with a perforated and cellular structure. It frequently contains embedded in it small masses of clay, quartz, or sandstone. In its native beds, a short way under the surface, it is so soft that it can be easily cut with a hatchet or spade; and when sufficiently compact, and not containing embedded portions of quartz, &c., it is cut into square masses like bricks, and used as a building-stone. Hence, Dr. Buchanan Hamilton names it latèrite or brick-stone; and its names in the native languages are derived from the same circumstance. When these square masses remain in the open air for some time they become very hard; and when not exposed to constant moisture they answer admirably as building-stones. Most of the handsome Roman Catholic churches at Goa are built of this laterite. In the principal fronts it is covered with plaster; but in other parts it is left bare, and retains its hardness when exposed to the atmosphere.

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## 2. EARTHY MINERALS.

1. *Corundum.*—Gray, green, blue, and red varieties of this very hard mineral, usually more or less perfectly crystallized, and ranging from opaque to translucent, occur embedded in granite and syenite in the district of Salem in the Madras Presidency, among the mountains of the Carnatic, and in other parts of the Peninsula. It is associated with cleavelandite, indianite, and fibrolite. Some varieties, as the blue, when cut in a hemispherical from, exhibit, when turned round, a white star with six rays. It is used as emery for polishing hard bodies.

2. *Spinel Ruby.*—This fine gem is found at Cananor, in the Mysore country.

3. *Beryl.*—The varieties of this gem at present most highly prized by the jeweller occur in a locality lately discovered at Cangayum, in the district of Coimbetoor, where they are associated with cleavelandite. The most beautiful cut beryl known is in the cabinet of the late M. H. P. Hope. In the language of the jeweller, its colour and transparency are perfect, and although weighing not more than six ounces, £500 sterling were paid for it. It is reported, although we believe erroneously, to have been found in Ceylon; for Mr Heath, who discovered and worked the beryl-mine of Cangayum, assures us, that beryl does not occur in Ceylon; and, therefore, as Mr. Hope's beryl was brought from India, it was very probably found in the Peninsula.

4. *Zircan.*—Fine specimens of this gem are met with in alluvial deposites in the district of Ellore.

5. *Schorlous Topaz.*—This interesting variety of topaz is mentioned by Dr. Heyne as occurring in different localities in syenite and granite districts.

6. *Schorl* and *Tourmaline* occur in granite, mica-slate, and in quartz-rock, bordering the granite and syenite districts

7. *Chrysolite.*—This gem occurs in the basaltic rocks of the secondary trap series in the great trap district already described.

8. *Precious Garnet.*—In many hills this gem abounds in syenite, in others it is embedded in mica-slate and gneiss.

9. *Pyrope.*—This beautiful mineral, the finest gem of the garnet family, is mentioned by Heyne as having been met with among the primitive rocks of the central parts of the Peninsula.

10. *Grenatite* has been found in the southern parts of the Mysore.

11. *Rock Crystal,* and other varieties of quartz, occur in the granite, mica-slate, and quartz-rock districts.

12. *Amethyst.*—This beautiful kind of quartz is met with, in greatest beauty, in drusy cavities of overlying trap in the great northern trap district.

13. *Cat's Eye*—Varieties of this ornamental quartz are

found in the alluvium of the river Krishna, also on the coast of Malabar.

14. *Carnelian.*—Mines, as they are called, of this ornamental stone occur in the principality of Rai Peempla, about thirty miles due east of Broach, and about five miles on the southern bank of the Nerbudda. The stones are obtained by sinking pits during the dry season in the channels of torrents. The nodules which are found in this way are intermixed with other rolled pebbles, and weigh from a few ounces to several pounds. Their colour, when recent, is dark olive-green, inclining to greenish-gray. The preparation which they undergo is, first, exposure to the sun for some time, and then calcination. The latter process is performed by packing the stones in earthen pots, and covering them with a layer five or six inches thick of dried goats dung. Fire is then applied, and in twelve hours the pots are sufficiently cool to be removed. The stones are now examined, and some are found to be red, others nearly white; the difference in their respective tints depending in part on the original quality of the colouring matter, and in part, perhaps, on the difference in the heat to which they have been exposed. The annual value of carnelian exported from India formerly amounted to £11,000. The great emporium for these articles is the ancient city of Cambay, where a very considerable trade is carried on by the Borah tribe, whose agents purchase the rough stones from the mountaineers, and convey them to Cambay where they are wrought into various ornamental articles. Such is the low price of labour and of material at Cambay, that a complete set of female ornaments, necklace, bracelets, cross, brooch, and ear-drops, ready for setting, agreeably to their colour aad quality, costs from eight to twenty-five rupees, the usual price; or, if very fine, from that sum upwards to fifty rupees for the most beautiful set that can be procured. Beautiful jaspers and agates are found in the carnelian district and other parts of India. In general these silicious minerals are derived from the overlying trap-rocks, in which they occur in cavities, embedded masses, and in veins.

15. *Zeolite.*—The great overlying trap district contains the principal species of this elegant family of minerals, which are generally found in drusy cavities.

16. The *felspars* and *micas* of the primitive districts, although apparently very interesting, have not hitherto engaged the attention of mineralogists. Of the hornblendes, the common, granular, slaty, acty-nolitic, and asbestine, have been met with; but we do not possess any information in regard to the *calcareous* and *barytic* minerals.

*Saline Minerals.*—Common salt, carbonate of soda, and nitrate of potash, as already mentioned, occur in considerable quantity in some districts, forming the salt, soda, and nitre soils,—but no beds of these minerals have as yet been met with in Southern India.

*Inflammable Minerals.—Diamond.*—This beautiful mineral, the most precious of all the gems, is found at Cudapa, Banaganpilly, &c., in the river-district of the Pennar; at Condapilly, in the district of the Krishna; near to Buddrachellum, in the bed of the Godavery; at Sumbhulpore, in the district of the Mahanuddy; and at Pannah, in Bundelcund. In all these so called diamond districts, there are deposites of sandstone and alluvium; and in some instances, at no great distance, appear igneous rocks, as trap and granite. The diamond is obtained by washing the alluvial sands, clays, loams, and conglomerates; it is said also to have been met with in the sandstone. If the diamond be of igneous origin, we might explain its occurrence in the sandstone by the action of igneous rocks under the sandstone; if of aqueous origin, by the gradual attraction and combination of the adamantine carbonaceous particles, diffused through the sandstone or alluvium. From facts in our possession, it is even not improbable that this gem may at times appear as a vegetable secretion, just as is the case with the silicious substance named tabasheer, found in the joints of the bamboo.

*Coal* is said to occur in connexion with some of the sandstone deposites, and *mineral oil* and *pitch* near to springs. *Sulphur*, although but in small quantity, was

found by Dr. Heyne near the Godavery, deposited from a shallow lake which extends several miles from north to south.

*Metalliferous Minerals.—Gold.*—This metal, although in small quantities, has been obtained by washing the alluvial soil of several of the rivers.—*Silver* also, but in small quantities, has been noticed in this quarter of India. *Iron.*—This metal in the states of oxide, hydrate, carbonate, and sulphuret, is met with in many parts of the Peninsula. Iron mines and forges occur in the Mysore, at Coimbetoor, Malabar, and in the Bundelcund country. At present the whole of the mining and metallurgical operations are in the hands of the natives, and consequently are carried on in the worst possible manner. *Iron* to any extent might be obtained from the great beds and veins distributed throughout the country, and sold at such a rate as to banish all foreign competition. *Copper.*—The general use of copper or brass utensils among the natives of India, and the preference given to them before all other kinds of vessels, seems to show that in all probability copper was formerly obtained in India in considerable quantity.* At present there are no copper mines of importance in any part of our Eastern empire; although, from the reports of travellers and naturalists, rich ores of copper are met with. The ores are *carbonate of copper*, or *malachite*, *anhydrous carbonate of copper*, which contains half its weight of metallic copper, *copper pyrites*, or yellow sulphuret of copper, and *gray copper ore*. *Lead* mines occur in Rajast'han.

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## 4. SUBMERGENCE AND UPRAISING OF LAND.

The account of Lieut. A. Burnes, who examined the Cutch portion of the delta of the Indus in 1826 and 1829, as stated by Mr. Lyell, furnishes the following very interesting details regarding the submergence and upraising of land during the earthquake of 1819:—A

* Colonel Tod says there are abundant copper mines in Rajast'han, and also mines of *tin*.

tract around Sindree, which subsided during the earthquake in June, 1819, was converted from dry land into sea in the course of a few hours; the new-formed *mere* extending for a distance of sixteen miles on either side of the fort, and probably exceeding in area the Lake of Geneva. Neither the rush of the sea into this new depression, nor the movement of the earthquake, threw down the small fort of Sindree, the interior of which is said to have become a tank, the water filling the space within the walls, and the four towers continuing to stand: so that on the day after the earthquake the people in the fort, who had ascended to the top of one of the towers, saved themselves in boats. Immediately after the shock, the inhabitants of Sindree saw, at the distance of five miles from the village, a *long elevated mound*, where previously there had been a low and perfectly level plain. To this *uplifted tract* they gave the mane of "Ullah Bund," or the "Mound of God," to distinguish it from an artificial barrier previously thrown across an arm of the Indus. It is already ascertained that this newly-raised country is *upwards of fifty miles* in length from east to west, running parallel to that line of subsidence which caused the ground around Sindree to be flooded. The breadth of this elevation from north to south is conjectured to be in some parts *sixteen miles*, and its greatest ascertained height above the original level of the delta is ten feet. This upraised land consist of clay filled with shells Besides "Ullah Bund," there appears to be another elevation south of Sindree, parallel to that before mentioned, regarding which, however, no exact information has been communicated. There is a tradition of an earthquake having, about three centuries, before, *upheaved* a large area of the bed of the sea, and converted it into land, in the district now called "The Runn," so that numerous harbours were laid dry, and ships were wrecked and engulfed; in confirmation of which account it was observed in 1819, that in the jets of black muddy water thrown out of fissures in that region, there were cast up numerous pieces of wrought iron and ship nails.

5. DESTRUCTION OF THE ANCIENT CITY OF OUGEIN AND OTHER PLACES IN INDIA BY A SHOWER OF VOLCANIC ASHES.

The valcono said to have burst forth in the districts of Cutch in 1819 is the only one of modern date mentioned by authors as having been observed in India. At an early period, in the time of the Rajah Vicramaditya, however, if we are to credit Hindoo story, a shower of volcanic earth or ashes overwhelmed the ancient city of Ougein and above eighty other places in Malwah and Baghur. The city which now bears the name is situated a mile to the southward of the ancient town. On digging on the spot where the latter is supposed to have stood, to the depth of fifteen or eighteen feet there are frequently discovered entire brick walls, pillars of stone, and pieces of wood of an extraordinary hardness, besides utensils of various kinds and ancient coins. In a ravine cut by the rains, from which several stone pillars had been dug, there was observed a space from twelve to fifteen feet long, and seven and eight feet high, composed of earthen vessels broken and closely compacted together. It was conjectured to have been a potter's kiln. Between this place and the new town is a hollow, in which tradition says, the river Sipparah formerly ran. It changed its course at the time the city was buried, and now runs to the westward. In the Asiatic Journal, the soil which covers Ougein is described as being of an ash-gray colour, with minute specks of black sand, thus somewhat resembling volcanic ashes. Captain Dangerfield observed, at a depth of thirty feet, in a so-called tufaceous mass, in the course of the Nerbudda near to the city of Mhysir, bricks and large earthen vessels, said to have belonged to the ancient city of Mhysir, destroyed by the catastrophe of Ougein. If, on more careful examination, it shall be proved that the earthy matter covering the ancient city of Ougein, and the beds of tufa-like deposite on the banks of the Nerbudda, and in many other parts of Malwah and Baghur, agree in characters

with the matters that cover Pompeii and Herculaneum, &c, we shall be entitled to infer, that the Hindoo "shower of ashes" proceeded from some volcano or volcanos, the remains of which may still be found in India.

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## 6. EARTHQUAKES.

The mountains, hills, valleys, and littoral plains of India, are sometimes agitated by subterranean concussions or earthquakes; but these tremblings and heavings of the solid mass of the country are not so frequent in India as in many other regions. Earthquakes are recorded as having occurred in the course of the Ganges in 1665, 1762, and in 1800. In 1803, an earthquake in the course of the Ganges occassioned great disasters, particularly at Barahat. But these agitations of the ground are not confined to the middle and lower parts of the course of this river, for Captain Hodgson experienced an earthquake near to its sources. He says, - "We lay down to rest; but between ten and eleven o'clock were awakened by the rocking of the ground, and on running out we saw the effects of an earthquake, and the dreadful situation in which we were placed, in the midst of masses of rock, some of them more than 100 feet in diameter, and which had fallen from the cliffs above us, probably brought down by some former earthquake. The scene around us, shown in all its dangers by the bright moonlight, was indeed very awful. On the second shock, rocks were hurled in every direction from the peaks around to the bed of the river, with a hideous noise not to be described, and never to be forgotten. After the crash caused by the falls near us had ceased, we could still hear the terrible sounds of heavy falls in the the more distant recesses of the mountains. We looked up with dismay at the cliffs over-head, expecting that the next shock would detach some ruins from them: had they fallen we could not have escaped, as the fragments from the summits would have tumbled over our heads, and we should have been buried by those from the middle. Providentially

there were no more shocks that night. This earthquake was felt in all parts of the mountains, as well as in the plains of the north-west provinces of Indostan."

On the 16th June, 1819, the western part of India was visited by an earthquake, which spread desolation and panic over a vast extent of country. It was felt from Bombay to beyond the tropic of Cancer; but the centre of the shock seems to have been in the province of Cutch, which suffered severely. The first and greatest shock took place on the 16th June, a few minutes before seven P. M. The wretched inhabitants of Bhooj were seen flying in all directions to escape from their falling habitations. A heavy appalling noise,—the violent undulatory motion of the ground,—the crash of the buildings,—and the dismay and terror which appeared in every countenance, produced a sensation fearful beyond description. The shock lasted from two to three minutes, in which short period the city of Bhooj was almost levelled to the ground. The walls, from the sandy nature of the stone, were crumbled into dust; nearly all the towers and gateways were demolished; and the houses left standing were so shattered as to be uninhabitable. It was calculated that nearly 2000 persons perished at Bhooj alone.

The devastation was general throughout Cutch. In other quarters its effects appear to have been equally disastrous. Thus, from Ahmedabad, the capital of Guzerat, we have the following description:—"This city is justly celebrated for its beautiful buildings of stone and other materials, and for the famous shaking minarets, which were admired by every stranger. Alas! the devastation caused by this commotion of the earth is truly lamentable. The proud spires of the great mosque erected by Sultan Ahmed, which have stood nearly 450 years, have tumbled to the ground within a few yards of the spot where they once reared their heads! Another mosque of elegant structure, which lies to the left of the road leading to Shahee Bagh, has shared the same fate. The magnificent towers, which formed the grand entrance into the citadel, have been much shaken and cracked in several places. The fort and town of Jelelsheer are

reduced to ruins. Many of the people killed were already out of doors, which is usually considered a situation of comparative safety. A marriage was about to be celebrated in a rich man's family, and the castes had assembled from various distant quarters; the shock occurred when they were feasting in the streets, and upwards of 500 of the party were smothered in the ruins of the falling houses."

The effects of this earthquake were indeed so extensive that we cannot afford room for more minute particulars; but we may add some account of the sensations felt by individual sufferers during the continuance of the shocks. In the British camp, which was pitched in a plain between the fort and city of Bhooj, the general feeling was an unpleasant giddines of the head and sickness of stomach, from the heaving of the ground; and during the time the shock lasted some sat down instinctively, and others threw themselves on the ground. Those who were on horseback were obliged to dismount; the earth shook so violently that the horses could with difficulty keep their feet; and the riders, when upon the ground, were scarcely able to stand. At Ahmedabad, "all the disagreeable sensations were experienced of being tossed in a ship at sea in a swell; and the rocking was so great, that every moment we expected the earth to open under our feet." One gentleman, writing from Surat, where the earthquake began at twenty minutes past seven, says, "The vibration of the couch I was lying on was so great, that I was glad to get off it;—the house was considerably agitated,—the furniture all in motion; a small table close to me kept striking the wall, and the lamps swung violently. I ran down stairs, and got out of my house as fast as possible. On getting on the outside, I found a number of people collected, gazing with astonishment at my house, which stands alone, and was so violently agitated that I expected it to fall down. The earth was convulsed under our feet." Another writes thus from Baroach,—"Such of the houses as are elevated, and at all loosely built, creaked like the masts and rigging of a ship in a gale; the venetians and window-

frames rattling violently, and the buildings threatening immediately to fall; a considerable lateral motion was impressed on every thing that admitted of it. After this more violent concussion had lasted a minute or upwards, it was succeeded by an oscillatory motion, of a more equable character, which continued for more than a minute and a half, making the whole period of the convulsion nearer three than two and a half minutes." An intelligent native residing in Iseria gives the following account: —" Yesterday, in the evening, a noise issued from the earth like the beating of the *nobut*, and occasioned a trembling of all the people; it appeared most wonderful, and deprived us all of our senses, so that we could not see, every thing appearing dark before us; a dizziness came upon many people, so that they fell down." The inhabitants of Cutch, however, were much relieved from the dread of farther convulsions by the circumstance of a volcano having opened on a hill about thirty miles from Bhooj; and, about ten days after the first shock, a loud noise like the discharge of cannon was heard at Porebunder. The sound came from the east, and was supposed to indicate the bursting of one or more volcanos in that direction. The earthquake affected in a remarkable degree the eastern and almost deserted channel of the Indus, which it re-filled and deepened.

# APPENDIX.

## (A.)

Baboo Ramcumul Sen in the preface to his valuable Bengalee Dictionary, speaking of Bengal, says, " The country is also called Gour, and appears to have been principally, or at least a considerable portion of it, recovered from the Sea, out of the Bay of Bengal; that is to say, as far as the borders of Rajmahal, including the 24 Pergunnahs, Midnapore and Jessore. It was first churrah or alluvial, and then *jungle* or forest, a portion of which is still to be found, and is called the Soonderbun. It was afterwards gradually cleared and inhabited. When Sevananda Majoomdar, the uncle of Raja Pratapaditya, who was the founder of the city of Jessore, fixed his residence there about three hundred years ago, it was a forest on the borders of the Sea.

Bengal first began to be peopled perhaps within 1000 years; as there is no chronology of the country extant, as there is of the other parts of Hindostan, the time affixed is nearly conjectural. As to what has been said of its having been obtained from the Sea, the following proofs are given. The fact appears probable from the following names of various villages which are contained in it. Suk Sagar Dry Sea, Chakradwipa Circular Island, Navodwipa or Nudea New Island, Agradwipa Foremost Island, Doomurdaha Dumboor Darga, Naldi or Naladwipa Nalás Island, Chundradwipa, Chandra's Island, Maldaha Malás Abyss, Gáokhál Gao's Creek, Madhukali Madhas Creek, Naladanga Nalás, Upland Bahmandángá Braman's Upland &c. &c.

These were no doubt alluvial lands, as the affixes, Sagar, Sea; Dwipa Island; Khala Creek; Darga Upland; Daha Abyss, relate to the sea or to water, and cannot be applied to any thing but land thus acquired.

2d. The boring for springs in Bengal shews that the rod does not meet the original stratum before it has penetrated 180 feet below the surface, which must therefore be the alluvial stratum. In excavating a tank or hole from 20 to 30 feet in depth, decayed boats, naval stores, and trunks of large trees have been found."

It has also been asserted that the scite of the town of *Sagor* in the N. W. of Hindostan, was formerly covered by the ocean. ED.

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## (B.)

### *Summary of Meteorological Observations made at the Surveyor General's Office in Calcutta, during the Years* 1829-30-31.

The monthly tables kept by the Surveyor General, and uniformly published in the GLEANINGS, since its commencement, are now capable of furnishing three years data for the illustration of the climate of Calcutta, as regards the pressure, temperature, moisture, rain, state of the winds, and aspect of the sky: and as such regularity prevails in atmospherical phenomena within the tropics, there is no occasion for further delay in presenting our readers with a summary of the results, adding a few observations and comparisons with such other registers of Oriental climates as are within our reach. Meteorology is now attracting more and more attention in Europe. Societies have been established for its exclusive cultivation in some countries, and more recently at Paris, a "correspondence pour l'avancement de la meteorologie" has been undertaken by M. Morin, who not only hopes to frame a complete "histoire du tems" for the whole world, but even eventually to be able to predict the future weather of any climate from accurate analysis of the effects of past seasons: towards this laborious undertaking Mons. Morin invites assistance

from all those who are in the habit of recording their observations, and we with pleasure give circulation to his proposals in return for the copy of his Essays on Meteorology, with which he has kindly favored us; but we should rather recommend, [for our own sakes no less than to save labour to M. Morin himself,] that our pages should in the first instance be made the medium of his *Indian correspondence;* and we further recommend that the tables with which we may be favored, may be abstracted by observers in a convenient form for reference and comparison, such perhaps as we have prepared on the present occasion to exemplify the climate of Calcutta. We hope hereafter to lay before our readers some extracts from the Essays of M. Morin; they abound in curious remarks upon the phenomena which he has professedly engaged to study, not only from nature, but from written authorities in all the current languages of Europe, nay even from the Chinese manuscript of *Yowe-ling*, the Daniel of the celestial empire, now under translation by M. Brosset, which besides meteorological facts "contient encore beaucoup d'autres choses curièuses."

But the object of the present paper is to exhibit a tabular view of the climate of Bengal, from the registers already published in detail. These registers have been purely *instrumental*, for as M. Morin remarks there are two modes of observing the weather, one by means of fixed instruments, the other by a continual log-book of occular observations on the formation and dispersion of clouds, force and direction of winds, influence of the ground, hills, waters; of storms, lightning, auroræ, and so forth. In this department our registers are perhaps deficient, but the regularity of our seasons is such, that there is not the same interest in watching the sky as in the ever changeable tropics: it is no difficult matter here, to predict the course of seasons, and the occurrence of occasional gales and north-westers is almost the only phenomenon not restricted to stated periods in the revolution of our Indian year.

The first of the following tables comprehends the general range of the weather; the wind, the clouds and the rain: having the same letters to denote the nature of the clouds

as are applied in the monthly registers: zero denotes the absence of wind or cloud, and the degree of force or of prevalence of particular winds is shewn by the form or size of the type, appealing at once to the eye.

The south or south easterly monsoon prevails from the spring to the autumnal equinox, and northerly winds for the remainder of the year, there are intervals of calm and variable winds at the equinoxes and solstices: the registers do not particularize storms, but two or three very severe ones have occurred in the interval under review. We may instance the storm of May, 1830, which injured so many houses in Calcutta; and the gale of November, 1831, which committed such havoc in the Cuttack district. As a sample of the course and disastrous effects of these storms, we extract a description of the one last mentioned from Mr. G. A. Prinsep's recent work on Saugor Island.

" While these pages have been in the press, another inundation has occurred more destructive than that of 1823, at a period of the year when such an event was unknown in the upper part of the bay. Since the 22nd of October the northerly monsoon seemed to be steadily set in with a cloudless sky; and the freshness of the mornings, indicating an early and a long cold season, was the common subject of congratulation among the Europeans residing in Calcutta. A depression of less than a tenth of an inch in the Barometer on the 30th excited no attention: the day was fine as usual, with very light northerly airs; but towards evening, a veil of cirrus enfeebled the sun's rays, and some heavy clouds shewed themselves in the south east. At 8 P. M. a light puff or two from that quarter momentarily interrupted the northerly breeze, which had freshened a little, about the time that a gust from the same direction was felt in Howrah, strong and sudden, like a north-wester. At day-break, on the 31st, the sky was overcast with a drizzling rain, the wind rather fresh at N. E. and increasing: by noon it was blowing a gale, and at short intervals heavy showers succeeded each other, during the rest of the day: violent gusts after sunset reminded us of the storm in May last year. The direction of the wind was still N. E. to E. After midnight, it suddenly veered to the southward, blowing tempestuously for several hours. During the 1st, it came round to the S. W. abating in force with every fresh point of westing. The 2nd was a dull cloudy, cold day, with the wind at west to N. W. but the gale had ceased: while it continued, there fell about 2 inches of rain. The Barometer indicated at its lowest ins. 29.672 at 1 P. M. on the 31st, and at sunrise on the 1st November, being only a fall of 318 with reference to the highest point at which it stood on the 29th. But the river was unusually troubled, and much damage occurred among the boats: at Mr. Kyd's dock gates, the water rose to the mark of 21 feet 6 inches* in the night tide of the 31st, have been only at 11 feet 6 inches at high water in the morning, although, when the springs came on, the highest level was only 17 feet 9 inches in the night tide of the 4th. The low-water level was raised more than 5 feet, being by the mark

* Twenty feet by the river guage reduced to correspond with his tide tables. In the great storm of May, 1823, the water only rose to the mark of 20 feet (River 18 6) being 1 foot 4 inches above the proper level: the greatest difference was then at low water, the river level being 9 feet 3 inches, instead of 6 feet 4 inches, as it ought to have been by calculation.

18 feet, instead of 7 feet 10 inches, its proper level in the day tide of the 1st of November.

Such was the character of the storm at Calcutta, where few fallen trees exhibited signs of extraordinary violence. Indeed, it would seem to have been more sparing of its ravages here than almost in any place exposed to its influence. Hundreds of boats are said to have been lost upon the Ganges, some of them laden with Indigo; and a letter from Bancoorah reports the destruction of trees to have been very great in that neighbourhood. The weather at Saugor is thus described by a gentleman residing at Frentosh.

"30th October, 2 P. M. clouds gathering in the E. quarter—3 P. M. some drops of rain.

31st, morning, strong breeze from N. E. with light rain—increasing towards noon with heavy rain—evening, hard gale at E and heavy driving rain—9,30 P. M. blowing very hard from S. E. and the tide beginning to pass over the bunds of the estate—10 P. M. wind S. W. blowing a hurricane—trees and houses falling—the wooden bungalow shaking very much, and the water within a foot of the floor, which is raised between 5 and 6 feet above the ground.

1st November—wind S. W. moderating, but strong squally breezes all day from S. W. to W. S. W. without rain.

2nd—wind N. to N. W. and cloudy."

Here the gale was much more severe than that of 1823, and the water rose at least a foot higher over the land: but its greatest fury was spent in the Midnapore district, and on the unfortunate coasts of Kedgeree, Hidgelee, and Balasore. The large bunds of those coasts, behind which a numerous population slept in fancied security, were suddenly overwhelmed by a tremendous wave, sweeping away with resistless force every house and every article of property in the native villages, and destroying the paddy crops, all the cattle of an extensive tract of country, and a large portion of the inhabitants. Hundreds of cattle were seen floating past the ships at the Sand Heads. The Collector of Balasore, who with difficulty saved himself and his family, has given a frightful picture of the desolation around him, the atmosphere being infected by the carcases of men and animals, which the retiring waters had left scattered upon the ground. A letter from Cuttack, published in the newspapers, estimates the destruction of lives at 10,000, the entire population of 300 villages, which are said to have been annihilated by the waves. The inundation extended from Kedgeree as far as Cuttack, and even broke through the bunds at Culpee and Diamond Harbour, besides creating a tremendous bore of 5 feet in the Roopnarain, at Tumlook, which destroyed a great many boats and nearly all the people in them.

Saugor has been more fortunate than the opposite coast; but, although from age and the grass upon them, the bunds of all the estates were stronger, while at the same time they were in general longer than in 1823, and mostly in good repair; no part of the island has escaped inundation, except a few of the tanks—a very important exception, with reference to the time of year, and the number of persons dependent upon them for subsistence.

Most fortunately the storm came on during neap tides: had it occurred at any time between the 2nd and 6th November, the tide would have risen three feet six inches to four feet higher at Saugor, and the frail asylum of the fallen thatch of their house would have been swept away with most of the inhabitants. The destruction of lives would then perhaps have been as great upon the island, as it has been at Kedgeree, Hidgelee, and Balasore; and in those districts the desolation would have been awful indeed. Nor is it unlikely, that the inundation might have extended even to Calcutta, where the river would overflow its banks at less than 23 feet, (by Mr. Kyd's tide register,) which is but 3 feet above the level it attained."

By the papers it appears that a most severe hurricane was experienced at Manilla, a few days previous to this storm, and if the whole intervening space could be submitted to inquiry, a connection between the two might very probably be proved.

TABLE I.—*Winds, Rain, and aspect of the Sky, most prevalent at Calcutta, from three years' observations.*

| MONTH. | SUN-RISE. | | NOON. | | SUN SET. | | RAIN. |
|---|---|---|---|---|---|---|---|
| | *Winds.* | *Clouds.* | *Winds.* | *Clouds.* | *Winds.* | *Clouds.* | *Inches.* |
| | 0 | 0 | N ne. | 0 ci. | 0 n.w. | 0 | |
| January... | 0 nw. | 0 fogs | NW n. | 0 cu. | 0 | 0 | 0.00 |
| | 0 n.e | 0 | NW var. | 0 | 0 | 0 | |
| | 0 | morning | N var. | 0 ci. | 0 | 0 | |
| February.. | 0 ne, | fogs | NE var. | cir. cu. | n.e. 0 | 0 cum. | 0.53 |
| | 0 nw. | cir. | W var. | cum. | n.w. 0 | 0 cum. | |
| | ne. var. | 0 ci. | variable | cum. | 0 | 0 | |
| March..... | 0 | 0 ci. | SW var. | cum. st. | 0 s. | cum. | 0.74 |
| | se. sw. | 0 ci. | variable | cum. | s.e. | cir. | |
| | southerly | cum | SW SE | cum. ci. | *SE* | cir. | |
| April...... | 0 s. | cum. | S sw | cum. ci. | *SE* | cum. | 4.08 |
| | sw. se. | cir. | SE sw. | cum. | *S* var. | cu. ci. | |
| | 0 s. | cum. | S var. | cum. | *S* s.w. | cum. | |
| May...... | 0 s. | var. | S sw. | cum. str | *S* s.e. | cum. | 5.78 |
| | 0 se. | cir. | SSE | nim. ci. | *SE* | cum. ci. | |
| | sw. 0 | cum. | SE sw. | cum. str. | S | cum. str | |
| June...... | se. | var. | *SE* var. | cum. str. | *SE* | n. ci. s. | 16.71 |
| | s. 0 | var. | S .calms | cum. n. | *SE* | cum. str. | |
| | sw. se. | cir. str. | SE sw | cum. str. | sw. 0 | cum- st. | |
| July...... | 0 s. | cum. str. | var. *SE* | cir. n. | se. var. | ci. str. | 8.98 |
| | 0 se. v. | nim. | var. w. | nim. cu. | sw. var. | ci. cu. | |
| | s. | cum. str | SE | cum. str. | *SE* | cum str. | |
| August.... | se. | cum. str. | SE s | cum. str. | *SE* var. | cir. str. | 10.41 |
| | s. ne. | sun. str. | SE var. | cum. str. | *S* var. | cir. n. | |
| | 0 se. | cum. str | *SE* var. | cum. str. | *SE* | cum. str. | |
| September. | 0 | cum. str. | *S* var. | cum. str. | *S* sw. se. | cir. str. | 6.70 |
| | 0 s. ne. | cir. str. | variable | cum. cir. | variable | cum. ci. | |
| | 0 ne. se | cum. ci. | *E* var. | cum. | ne. 0 | cum. | |
| October... | 0 var. | cum. | *NE* var | cum. | 0 var | cum. | 5.84 |
| | 0 n. ne. | 0 cu. | *N* e.w. | cum. | ne. var. | cum. | |
| | 0 ne. | 0 | NE | cum. | *NW.* 0 | 0 | |
| November. | 0 n. | cir. | N var. | 0 | var. 0 | 0 cu. | 0.00 |
| | 0 | cir. | NE n | cum. | 0 n.e. | 0 ci. | |
| | 0 n. | 0 | NE nw. | 0 cu. | 0 n. | 0 | |
| December. | 0 n. | 0 | N nw. | 0 cum | 0 | 0 | 0.00 |
| | 0 | 0 | NW ne. | 0 c.s. | 0 n.w. | 0 | |

Average of Rain for three years, 59,83

## *Barometer and Thermometer.*

The next two tables require no explanation; they shew the usual range of the atmospherical pressure and temperature throughout the year.

The registers of the Barometer have been uniformly reduced to the temperature of 32° Fahr. which greatly facilitates their application to useful purposes. The periods of diurnal minima and maxima also have wisely been chosen for observation, but it is to be regretted that the same precaution could not have been extended to the parallel hours of the night.

TABLE II.—*Mean Atmospherical Pressure in Calcutta, for* 1829 30 31.

Barometer reduced to 32° Fahrenheit.

| Month. | Sun rise. | Maximum Pressure at 9 h 40 m. | Apparent noon. | for 1830 31) 2h 50m. P. M. | Minimum Pressure, 4 P. M. | Sun set. |
|---|---|---|---|---|---|---|
| | inches. | inches. | inches. | inches. | inches. | inches. |
| Jan. | 30.034 | 30.084 | 30.033 | 30.019 | 29.961 | 29.971 |
| Feb. | 29.959 | 29.995 | 29.960 | 29.904 | 29.878 | 29.892 |
| March, | .877 | .922 | .885 | .825 | .797 | .808 |
| April, | 748 | .796 | .763 | .721 | .672 | .685 |
| May, | .625 | .670 | .638 | .579 | .555 | .579 |
| June, | .526 | .563 | .532 | .497 | .468 | .484 |
| July, | .558 | .591 | .571 | .529 | .501 | .520 |
| Aug. | .589 | .624 | .599 | .532 | .525 | .537 |
| Sept | .655 | .700 | .667 | .6 6 | .599 | .609 |
| Oct. | .796 | .839 | .792 | .736 | .729 | .743 |
| Nov. | .935 | .978 | .928 | .875 | .871 | .916 |
| Dec | 30.038 | 30.079 | 30.025 | .971 | .965 | .978 |
| Means | 29.778 | 29.818 | 29.783 | 29.734 | 29.710 | 29.727 |

Mean of the columns of maxima and minima for three years, 29. 764

TABLE III.—*Mean Thermometrical Range for the same period.*

| Month. | Minimum temperature Sun rise. | IX. 40 A.M. | Apparent noon. | Maximum temperature 2h.50m P. M. | IV. P. M. | Sun-set. |
|---|---|---|---|---|---|---|
| Jan | 56°.8 | 67°.5 | 73°.5 | 77°.5 | 75°.3 | 70°.1 |
| Feb. | 63 6 | 74 7 | 77.9 | 82.1 | 82.0 | 76.5 |
| March, | 72 8 | 80.0 | 84 4 | 86.8 | 86.4 | 81.2 |
| April, | 76 6 | 85.8 | 89 6 | 91.2 | 90.5 | 85.3 |
| May, | 79.9 | 88.4 | 91.3 | 93.6 | 91.4 | 86.6 |
| June, | 80.5 | 85.6 | 88.6 | 88.1 | 86.8 | 83 8 |
| July, | 80.3 | 84 3 | 85 6 | 86.4 | 85.1 | 82 9 |
| August. | 79 4 | 84.4 | 85.5 | 85 3 | 84.4 | 82.5 |
| Sept | 79.4 | 84 9 | 86.1 | 85.6 | 84.7 | 82.9 |
| Oct. | 77.1 | 83 2 | 85.6 | 85 5 | 84.1 | 81.1 |
| Nov. | 66.7 | 74 8 | 78.8 | 80.1 | 78.7 | 75.4 |
| Dec | 59.7 | 69.7 | 74.9 | 76.8 | 75.4 | 70 9 |
| Means | 72 73 | 81.11 | 83.49 | 84.89 | 83.57 | 79.86 |

| | |
|---|---|
| Mean of extremes,.................... | 78.81 |
| Mean temperature of the day,.......... | 81.26 |
| of the night,........ | 75 00 |
| Deduced mean of the 24 hours,........ | 78.13 |
| Mean temperature of Calcutta, in 1784-5 | 78° 0 (As. Res. IV) |

To place the relative course of the two instruments in a more convenient form for comparison, the following tabular view of their range throughout the year has been constructed; and it derives additional utility from the parallel columns which we have been enabled to insert for other localities, so that the whole presents a convenient epitome of meteorological phenomena between 12° and 30° of north latitude. Of the climate of Madras, the minutest details are recorded in the voluminous and careful reports of the late astronomer Mr. Goldingham; whose results merely required to be reduced to the freezing point. The Ava

tables are abstracted from Major Burney's registers published in the GLEANINGS; the Benares tables are taken from the Oriental Magazine, 1827: for the Seháranpúr results we are indebted to Dr. Royle, who allowed us to look through his copious registers for the purpose. As the several Barometers were never absolutely compared together, entire dependence cannot be placed upon the mean altitudes given; but with regard to Calcutta, Benares, and Seháranpúr, as some opportunities occurred of comparison through the instruments of different travellers, the relative altitude of these places can be estimated tolerably well: Thus, Sehárapúr will be found to be almost exactly 1000 feet above the sea, as was before estimated by Captain Hodgson: —Benares in like manner may be safely stated in even numbers to be 300 feet above the sea.

TABLE.—IV*. *Monthly Deviations of the Barometer and Thermometer from their annual mean height at Calcutta; and at several other places, introduced for the sake of comparison.*

| Month. | Barometer at 32° Fahr. | | | | | Thermometer. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Madras mean of 21 years from 1796 to 1821. | Ava 1830. | Calcutta, for three years 1828-30 31. | Benares, four years' observations 1822 to 1826 | Seharanpur, 1826-27. | Madras, mean of 21 years' observations max. and min. | Ava, 1830, sun-rise and 4 P. M. | Calcutta, three years' observations max. and min. | Benares, four years' observations max. and min | Seharanpur, 1826-27. |
| | inch | inch | inch. | inch. | inch. | deg. | deg. | deg | deg. | deg |
| January. | +.146 | +.229 | +.208 | +.273 | +.274 | —6.5 | —13.7 | —11 6 | —17 0 | —21 8 |
| February, | +.131 | +.115 | +.172 | +.178 | +.210 | —4.5 | — 4.9 | — 6 0 | —11.5 | —20 9 |
| March. | +.087 | +.051 | +.095 | +.107 | +.151 | —1.8 | — 2.8 | + 1.0 | — 1.5 | + 0 1 |
| April, | —.006 | —.028 | —.030 | —.043 | +.061 | +0.7 | + 7.8 | + 5 1 | + 9.5 | + 6.1 |
| May, | —.124 | —.105 | —.152 | —.136 | —.060 | +5.2 | + 5.6 | + 7 5 | +13 9 | +11.6 |
| June, | —.117 | —.150 | —.248 | —.289 | —.217 | +7.1 | + 7.1 | + 6 5 | +13 1 | +17.5 |
| July, | —.103 | —.176 | —.218 | —.308 | —.398 | +3 9 | + 4.4 | + 4 6 | + 6.9 | +12.8 |
| August, | —.088 | —.126 | —.194 | —.203 | —.278 | +3.0 | + 4.1 | + 3.6 | + 6.4 | +10.0 |
| September, | —.057 | —.098 | —.115 | —.098 | —.158 | +2.1 | + 4.3 | + 3.7 | + 5 8 | + 9.5 |
| October, | —.018 | —.010 | +.020 | +.074 | —.047 | +0.1 | + 2.2 | + 2.5 | + 1.3 | — 0 8 |
| November, | +.006 | +.102 | +.161 | +.181 | +.209 | —3 1 | — 4.2 | — 5 1 | — 9.7 | —10.8 |
| December, | +.124 | +.201 | +.258 | +.270 | +.245 | —4.9 | —10.1 | —11.5 | —17.6 | —13.8 |
| Ann. mean | 29.810 | 29.673 | 29.764 | 29.464 | 28.766 | 81.60 | 78.30 | 78.13 | 77.81 | 73.5 |
| | .270 | .405 | .506 | .587 | .672 | 13.9 | 21.7 | 19 1 | 31 5 | 39.3 |

It will be remarked that the range of variation in the weight of the atmosphere increases with the latitude, even up to the foot of the Himalaya mountains, and that it is accompanied by a corresponding increase in the range of

the thermometer. We have elsewhere reasoned on this subject, and do not intend, in the present view of observed facts, to enter into any theoretical discussions; at any rate before doing so it is to be wished that we may be able to extend the table of comparisons to other principal points on the continent of India; It is evident that in calculating barometrical altitudes, by corresponding observations at distant places, a corrective equation must be introduced, depending on the time of year, having its maxima at the two solstices.

We now come to the *diurnal oscillation* of the Barometer, for which the same sources have furnished me with materials for framing a comparative table for five localities considerably distant from one another; we could have added Murshedabád to the list, but that the thermometric series for that place was incomplete. At Seháranpúr the horary observations were confined to a single day, the fifteenth, of each month. At Madras to three similar days: at Benares perhaps the hour of the minimum was not always exactly observed: thus a little irregularity must be expected, but on the whole the results are wonderfully equable.*

TABLE V. *Diurnal Oscillations of the Barometer and Thermometer at Calcutta, with comparative observations at other places.*

| Month | Barometer at 32°. Madras, max and min every tenth day for 1823 | Ava, 10 A M and 4 P M | Calcutta, 9 40 A M and 4 0 P M | Benares, 9 to 10½ A M and 4 to 6 P M | Seháranpúr, max and min of one day in month | Thermometer. Madras, 4 A M and 2 P M | Ava, sunrise and 4 P M | Calcutta, sunrise and 2 30 P M | Benares, daily extremes by register thermometer | Seháranpúr extremes of one day in each month. |
|---|---|---|---|---|---|---|---|---|---|---|
| | inch | inch | inch | inch | inch | deg. | deg. | deg. | deg. | deg. |
| January, | 072 | 111 | .123 | 097 | 103 | 11 0 | 9 4 | 26 7 | 17 8 | 24.5 |
| February, | 070 | 128 | 117 | 103 | 093 | 10 0 | 16 8 | 18 5 | 19 2 | 21 0 |
| March, | 076 | 137 | .125 | 121 | 116 | 7 0 | 20 8 | 14 0 | 20 7 | 26 0 |
| April | 081 | 1[illegible]0 | 121 | 1[illegible]5 | 107 | 9 0 | 20 9 | 11 6 | 24 2 | 31.0 |
| May, | 081 | 113 | 115 | 124 | 160 | 9 0 | 20 1 | 13 7 | 21 0 | 38 0 |
| June, | 092 | 126 | 095 | 113 | 178 | 9 0 | 9 0 | 7 6 | 16 4 | 31.5 |
| July, | 0[illegible]7 | 133 | 099 | 077 | 103 | 7 0 | 6 6 | 6 1 | 9 0 | 17 3 |
| August, | 105 | 109 | .099 | 088 | 079 | 7 0 | 8 8 | 5 9 | 8 3 | 11.5 |
| September, | 094 | 145 | 101 | 163 | 1[illegible]3 | 6 0 | 7 8 | 6 2 | 10 3 | 13 0 |
| October | 068 | 111 | 110 | 160 | 120 | 8 0 | 5 0 | 8 1 | 18 1 | 31 5 |
| November, | 071 | 127 | 107 | 107 | .117 | 8 0 | 6 7 | 13 4 | 16 8 | 29 3 |
| December, | 071 | 126 | .1[illegible]4 | 098 | .124 | 9 0 | 8 5 | 17 1 | 16 3 | 17.5 |
| Mean tide | 081 | 126 | 110 | 107 | 120 | 8 5 | 10 6 | 12 2 | 16 6 | 24.2 |

With due allowance for the difference of sensibility in the instruments, the above table shews that the average diurnal tide of the Barometer between the equator and 30° north latitude exceeds one-tenth of an inch, and that it is progressively greater as the variation of temperature during the day is also greater. With regard to the *nocturnal tide* of the atmosphere, the Calcutta tables afford us no data, for want of an observation at 10 P. M., the hour of the supposed maximum at night; all that is indicated therein is, that the Barometer is constantly *lower* at sunset than at sun-rise. At the Madras observatory, in 1823, a series of horary observations was made for three days in each month, which seems to establish the fact of a night-tide beyond a doubt to the extent of .04 inch; when however the corrections for the temperature of the mercury are applied, this amount is reduced to two-hundredths of an inch, which is one-fifth only of the *diurnal tide*.

The same result is obtained from a month's horary observations undertaken by Col. Balfour at Calcutta, in the year 1784. We have also in manuscript a diary kept by Mr. G. A. Prinsep, during 32 days of a voyage from Calcutta to Bombay, whence it appears that upon the ocean the

| | | | | | | |
|---|---|---|---|---|---|---|
| Barometer | falls | from | 10 P. M. | to | sunrise | —.022 |
| | rises | from | sunrise | to | 10 A. M. | +.044 |
| | falls | from | 10 P. M. | to | 4 P. M. | —.102 |
| | rises | from | 4 P. M. | to | 10 P. M. | +.080 |

on the other hand, the Berhampúr register exhibits a constant *rise* from 10 P. M. to 5 A. M. but as the corresponding thermometrical register is unfortunately not in our possession, we have been obliged to substitute a correction from the means of the Calcutta register, and the results may be in some measure erroneous: they cannot however be so far from the truth as to reverse the apparent issue. At Sehàranpúr also the existence of a noctural tide is equivocal; the following table exhibits all that we can gather towards the elucidation of the point in India, expressing by minus signs the real tide, or fall of the barometer, from 10 P. M. to 5 A. M, and vice versâ.

TABLE VI. *Nocturnal Oscillation of the Barometer from* 10 P. M. *to* 5 A. M. *reduced to* 3[illegible]° *Fah*

| Month | Madras 3 days in each month | Berhampur, from Dr. Russel's tables | Seharanpur, Dr Royle's, observations. | Vera Cruz in Mexico by Fray Juan. |
|---|---|---|---|---|
| January, | — 004 | + 034 | —.043 | + 018 |
| February, | — 029 | + 026 | — 009 | +.009 |
| March, | — 026 | + 069 | — 008 | —.002 |
| April, | — 027 | +.008 | — 007 | +.008 |
| May, | — 014 | + 020 | — 020 | + 005 |
| June, | — 026 | + 012 | + 030 | +.003 |
| July, | — 009 | .000 | — 005 | — 002 |
| August, | — 028 | + 014 | — 016 | —.007 |
| September, | — 021 | + 011 | + 011 | — 012 |
| October, | — 033 | + 009 | — 004 | —.021 |
| November, | — 010 | + 009 | + 021 | +.001 |
| December, | — 019 | + 027 | + 015 | — 023 |
| Means . | — [illegible] | + [illegible] | — 001 | —.002 |

The last column is taken from the manuscript observations of Fray Juan, at Vera Cruz in 1817-18, in the possession of a friend: the latitude of that place, 19° N., should make the results applicable here

There is still sufficient ambiguity respecting this second tide, therefore to render further inquiry necessary, and it would be desirable to employ a barometer for the purpose, which should not require to have any correction applied for the temperature of the mercury; this might be easily effected by enclosing the barometer tube in an outer tube of the same length, also filled with mercury upon the surface of which the scale might float.

## *Hygrometry.*

The Calcutta tables afford sufficient data for calculating the state of the air with respect to moisture, whenever the temperature of an evaporating surface can be converted with certainty into equivalent *expressions of* the more *obvious* phemomena of Hygrometry, such as the *tension* or relative dryness; or the absolute quantity of aqueous vapour contained in a given space.—The first of these points may be found within the limit of 2 or 3 per cent. by the tables published in the first volume of the GLEANINGS:—and the second may easily be calculated therefrom by the formulæ of Dalton or Ure. In the following tables this had been done, and the uniformity of the results is satisfactory enough August is the most damp month of the year to the sense; but June is the month in which the atmosphere is

really loaded with the greatest weight of aqueous vapour. January is in every respect the driest season of the year, but the drought at Calcutta naturally falls far short of what is experienced at Benares and Scháranpúr, where the depression of the moistened thermometer sometimes exceeds 35 degrees.

**Table VII.** *Depression of the Wet bulb Thermometer and deduced Tension of Vapour in the atmosphere, at Calcutta*, 1829-30 31.

| Month. | Sunrise. | | 9 40 a. m. | | Noon. | | 2 50 p. m. | | 4 p. m. | | Sunset. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dep. | Ten. | Dep. | Ten. | Dep. | Ten. | Dep. | Ten. | Dep. | Ten. | Dep. | Ten. |
| Jan. | 2° 3 | .82. | 8°.4 | .51 | 13°.1 | .37 | 15°.9 | .31 | 14°.4 | .32 | 9°.3 | .50 |
| Feb. | 1 .6 | .87 | 8 .5 | .56 | 12 .4 | .44 | 14 .4 | .38 | 13 .9 | .39 | 11 .1 | .47 |
| March, | 1 .9 | .89 | 8 .7 | .59 | 12 .6 | .47 | 14 .2 | .41 | 14 .1 | .41 | 10 .7 | .51 |
| April, | 1 .4 | .94 | 8 .1 | .66 | 11 .7 | .53 | 13 .9 | .46 | 12 .7 | .50 | 8 .1 | .61 |
| May, | 1 .8 | .92 | 7 .3 | .69 | 9 .8 | 62 | 10 8 | .58 | 9 .7 | .61 | 6 .0 | .73 |
| June, | 1 .6 | .92 | 4 .4 | .78 | 6 .6 | .71 | 6 .6 | .73 | 5 .2 | .76 | 0 .5 | 83 |
| July, | 1 .9 | .90 | 4 .6 | .79 | 5 .5 | .75 | 5 .5 | .74 | 5 .0 | .77 | 3 5 | .83 |
| August, | 1 .6 | .93 | 4 .4 | .80 | 5 .4 | .77 | 4 .9 | .77 | 4 .8 | .78 | 3 .1 | .85 |
| Sept. | 1 .7 | 91 | 5 .3 | .76 | 6 .5 | .71 | 5 .8 | .73 | 5 .2 | .76 | 3 .8 | .81 |
| Oct. | 1 .5 | .92 | 6 .1 | .71 | 8 .0 | .65 | 8 .6 | .63 | 7 .4 | .66 | 4 3 | .79 |
| Nov. | 2 .8 | .85 | 9 .0 | .55 | 12 .3 | .44 | 13 .9 | .40 | 12 6 | .43 | 8 .1 | 59 |
| Dec. | 2 .4 | .83 | 7 4. | .59 | 10 .8 | .47 | 12 .5 | .43 | 11 .3 | .41 | 6 .9 | .61 |
| Mean Tension | | .892 | | .665 | | .577 | | .547 | | .570 | | 680 |

**Table VIII.** *Mean Barometric Pressure of Aqueous Vapour in the Air during the same period, deduced from Table VII, and Dalton's Table of Aqueous Tensions.*

| Month. | Sunrise. | h. m. 9 40 a. m. | Noon. | h. m. 2 50 p. m | 4 p. m | Sunset |
|---|---|---|---|---|---|---|
| | inch. | inch. | inch. | inch. | inch. | inch |
| January,............ | 0.336 | 0.336 | 0.300 | 0.288 | 0.275 | 0.275 |
| February,............ | .513 | .476 | .413 | .407 | .300 | .103 |
| March, ............ | .703 | .590 | .546 | .501 | .500 | .535 |
| April,............ | .816 | .792 | .721 | .649 | 690 | .755 |
| May,............ | .901 | .931 | .911 | .911 | .902 | 911 |
| June,............ | .991 | .980 | .975 | .985 | .905 | 987 |
| July,............ | .909 | .908 | .900 | .903 | .901 | .910 |
| August,............ | .911 | .920 | .916 | .914 | .897 | .926 |
| September,............ | 892 | .889 | .859 | .869 | .887 | .861 |
| October,............ | .810 | .788 | .773 | .738 | .760 | .814 |
| November,............ | .588 | .495 | .419 | .424 | .422 | .513 |
| December,............ | .465 | .456 | .424 | .413 | 404 | .485 |
| Means,............ | .751 | .713 | .682 | .667 | .669 | .710 |

It is here observable, that besides the *apparent* drying of the air caused by the increase of heat during the day, it actually seems to become less loaded with moisture from sun-rise to 3 P. M. to the extent of about 10 per cent : this is not easily explained without recourse to suppositious errors of the instruments or of the formulæ of calculation; for it is difficult to imagine that the vapour should rise independently of the air with which it is mingled; or if it

does rise, that it should fall again so rapidly, to resume its place in the lower atmosphere on the following morning.—It might be expected à priori that where fogs prevailed in the morning, or where dew was deposited, the pressure of aqueous vapour measured in the morning would be less than in the middle of the day; and the appearance of a contrary result, if it does not point to a probability of errors in the instruments, or in the experiments upon which the calculations are grounded, tends at any rate to show that much remains to be done to explain facts, and to place this branch of meteorological inquiry upon a firm basis.

It is however some satisfaction to know that the register, kept at the surveyor general's office, is in this, as well as other respects, superior to most of those published in the scientific journals of England, where the column devoted to the hygrometer is generally a mere mass of figures convertible to no useful purpose. It is to be hoped, that all who register their observations in India will adopt the same kind of hygrometer, namely a thermometer with a bulb projecting from the scale, and covered with a wetted muslin bag. Its indications should first be carefully compared with the dry thermometer, and corrected for any errors of division.

(C.)

*Mirage in India.*

It is not generally known that the mirage, apparently first brought to the notice of modern Europeans by the French army in Egypt, is visible in the central parts of Hindustan. In Rajpútana it is necessarily of constant occurrence; but in the less arid plains to the eastward it is also to be seen. At Ghazipur, between the European bazar and the stables of the Company's stud, there is a level, extending about a mile; from the east end of which may very often be seen, about half a degree under the western horizon, the appearance of a sheet of water about 1° in width and perhaps 10° in length from right to left, in which the sky, houses, trees, and animals are reflected as in a bright mirror.